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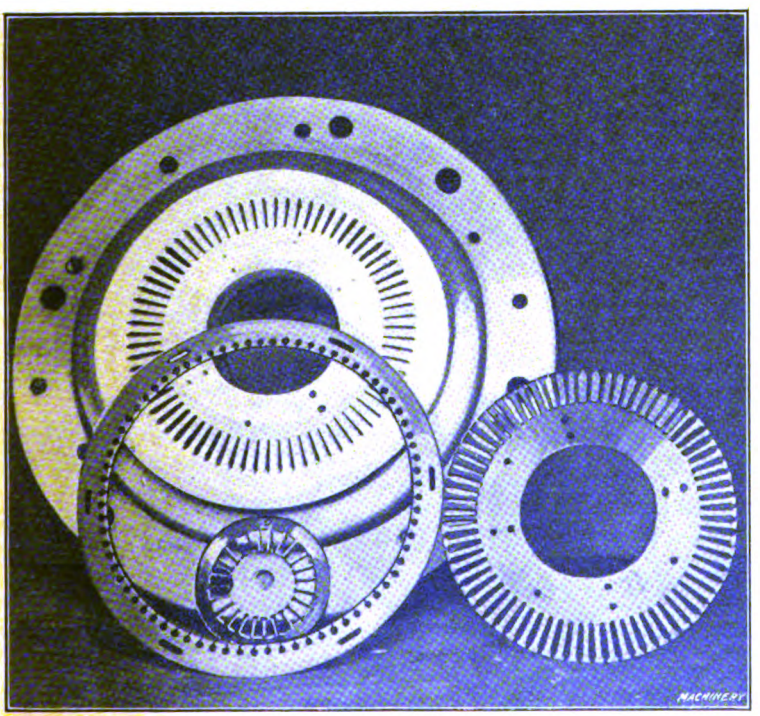
MODERN BLANKING AND PIERCING DIES



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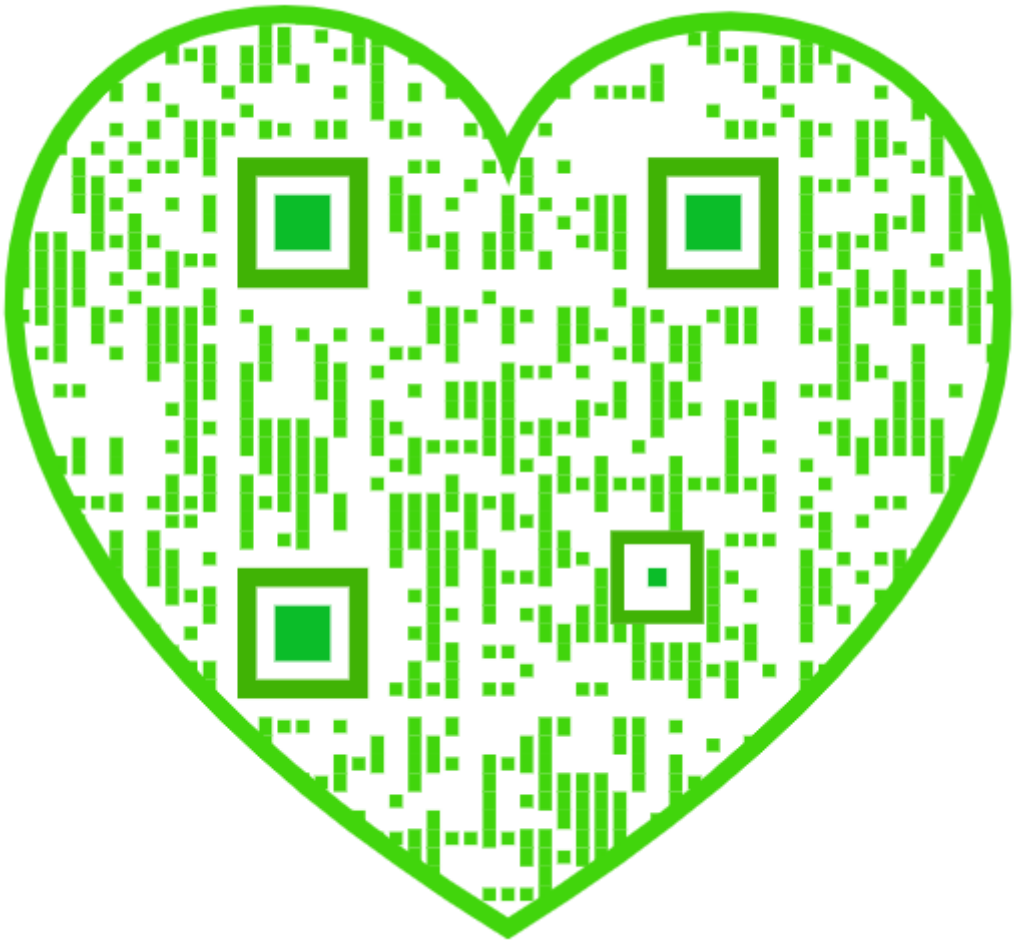

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MODERN BLANKING AND PIERCING DIES

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CHAPTER I

BLANKING AND PIERCING DIES

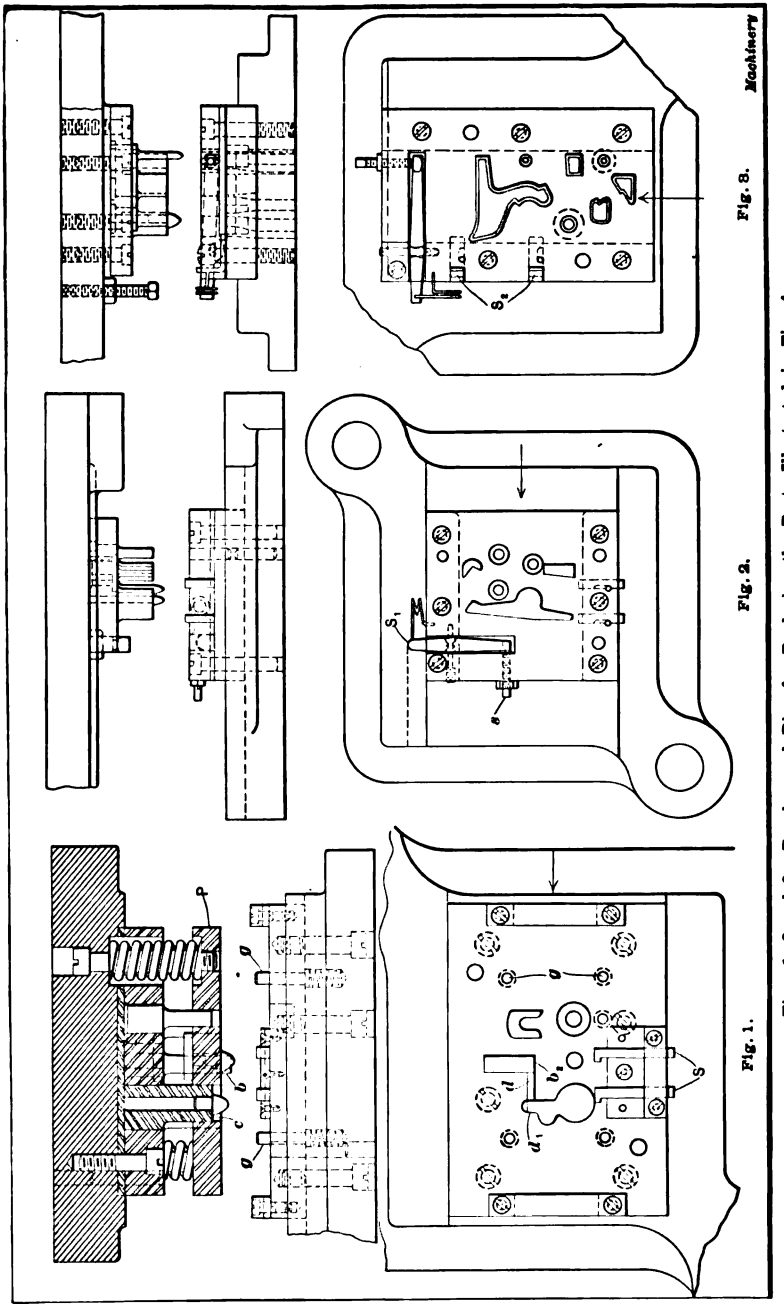
Punches and dies are made in such a variety of designs and for so many different purposes that it is difficult, if not impossible, to treat the subject of die construction and design in a general way and present fundamental principles which can be applied universally in the art of diemaking. For that reason, diemakers in describing their methods and practice have almost invariably confined their articles to specific die designs instead of attempting to deal with the theories of the subject. Contributions of this kind, relating to dies which have been in actual use, are, undoubtedly, of great practical value because they show what has been accomplished and often suggest a method or design that can be used for other classes of work.

In this book various forms of blanking and piercing dies are illustrated and described. All of these designs are, of course, special in the sense that they are intended for producing some particular part, and, at first thought, it might seem useless to study the details of a die which, in all probability, will not exactly be duplicated within the experience of any one toolmaker or diemaker. It should be remembered, however, that the best way to obtain a broad, general knowledge of die construction is by studying as many different designs as possible, in order to become familiar with the constructional features which have proved successful in actual practice. Therefore, this treatise deals chiefly with various punch and die designs, and also the methods employed in connection with their construction. Incidentally, some of the tools illustrated represent ingenious types which are the development of long experience in the art of constructing dies.

Examples of Modern Blanking and Piercing Dies

Some interesting examples of die work taken from the diemaking department of the Taft-Peirce Manufacturing Co., Woonsocket, R. I., are shown in Figs. 1, 2, and 3. While the dies illustrated are used to produce comparatively plain parts, there are some points in their construction which may be of interest and value, particularly to those not experienced in the art of diemaking.

The die shown in Fig. 1 is for producing the part illustrated at *A* in Fig. 4, which also shows the successive piercing, bending and blanking operations. The stock is fed through the die in the direction indicated by the arrow. On the first stroke the piercing operation at *a* is performed by punches of corresponding shape. On the next stroke a bending punch turns over the part b_1, making a right-angle bend, and, finally, the finished piece is blanked out. Of course these operations



Figs. 1, 2 and 3. Punches and Dies for Producing the Parts Illustrated in Fig. 4

all take place simultaneously, except when the stock is first being started, so that a finished piece is blanked out at each stroke.

One of the interesting features of this die is the method of stopping the stock as it is fed forward. After the bending operation, which takes place at b_2 on the die (see Fig. 1), the bent end b_1 (Fig. 4) which projects downward below the surface of the die, is fed forward through channel d until it comes against the end d_1 which forms a positive stop. By this simple method, the stock is located for the pilot pins which accurately position it for the blanking operation. By means of the spring pressure-pad P, the stock is held firmly against the die, so that it will not be buckled by the bending operation. When the stock is first being started through the die, stops S, which may be moved in or out as required, are used for locating the stock for the first and second operations.

The die shown in Fig. 2 is for piercing and blanking the pawl illustrated at B in Fig. 4, which also shows a sample of the scrap. As the V-shaped projection h on one end of this pawl, and the straight surface i, had to have a smooth finish, a shaving operation on these surfaces was required. This operation is not performed in a shaving die after blanking, as would be necessary if the entire contour of the part had to be finished, but it is done in the blanking die by removing a certain amount of metal adjacent to these surfaces, as at j and k, during the piercing operation. The result is that when the pawl is blanked, the edges opposite the openings j and k are subjected to a shaving action which leaves a smooth surface that is entirely free from the roughness found on the other edges where the stock is sheared from the solid.

The narrow shavings which are removed from the surfaces to be finished, remain attached to the scrap in this particular instance, as the illustration shows. It will be seen that when this method of securing a finished edge is employed, the stock must be accurately located, as the removal of a shaving that is too thick would roughen the edge. In the die illustrated, the stock is located by the two pilot pins on the punch, one entering the hole n, Fig. 4, and the other a hole o pierced simply to give a two-point location, thus insuring accuracy. In practice it has been found that a shaving equal to 10 per cent of the stock thickness is about right for mild steel.

This die is equipped with an automatic stop S_1 which is operated by a projecting screw on the punch in the usual way. The hole in this stop for the pivot on which it swivels is tapered toward the center from both sides, thus giving it a movement horizontally as well as vertically. With the stop mounted in this way, slight adjustments to compensate for any error there might be in the location of the stop with reference to the pilots in the punch, can easily be made when the die is being tried out, by simply turning the screw s until the stop is properly positioned. The function of the stop is, of course, to locate the stock approximately and its flexibility prevents the pilots from being subjected to excessive strains. This horizontal adjust-

ment has an additional advantage in that the stop does not have to be located so accurately when this adjustment is provided.

Another punch and die of the piercing, shaving and blanking type is shown in Fig. 3. In this case the work *C* in Fig. 4 had to be finished in three places, as shown by the perforations at *p*, *q* and *r*. The stock is fed in the direction of the arrow (Fig. 3) and is pierced for shaving by the three punches while two other punches pierce the holes t_1 and t_2, Fig. 4. The hole t_1 is merely for locating purposes,

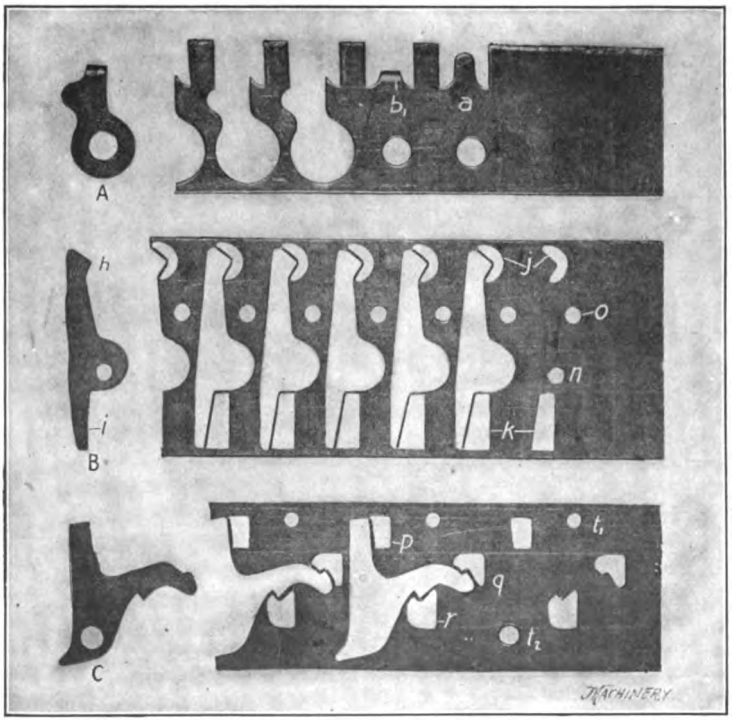


Fig. 4. Blanked Parts and Scrap, Illustrating Successive Operations

there being two pilots which give a two-point location. This die is also equipped with an automatic stop similar to the one described in connection with Fig. 3, and it has small hand stops S_2 which are also common to the designs previously referred to.

Button Back Blanking and Piercing Die

A cross-sectional view of an interesting design of punch and die used for blanking and piercing metal backs used on trouser buttons is shown in Fig. 5. No. 19 Birmingham gage (0.042 inch thick) ribbon stock is used for making these button backs and the metal is not of a particularly good quality. Fig. 6 shows an enlarged view of one of the finished button backs, and Fig. 7 illustrates the location of the

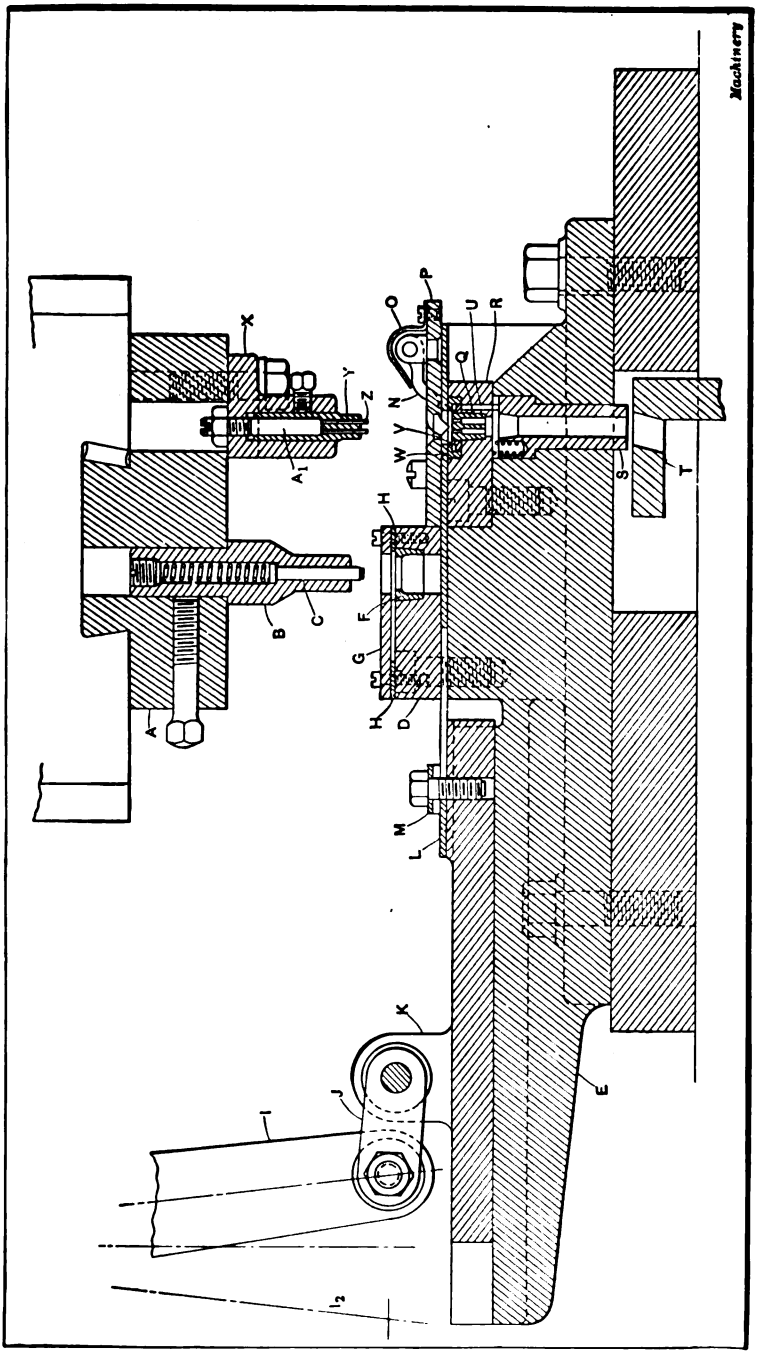


Fig. 6. Cross-sectional View of Button Back Blanking and Piercing Punch and Die

holes in a piece of scrap metal, from which it will be seen that the method of blanking requires very little stock to be wasted.

Referring to the cross-sectional view through the punch and die, *A* is the punch block in which three blanking punches *B* are set in the positions indicated by the cross-sectioned holes in Fig. 7. These punches are held in place by set-screws and are equipped with spring plungers *C* for ejecting the work from the die. The blanking die-holder *D* is screwed to the cast-iron shoe *E;* this holder is made of machine steel and has three tool steel blanking dies *F*, which have a three-degree taper on the outside. *G* is the stripper plate for the dies. The ribbon stock is fed through the die between the guides *H*, and as the ram of the press descends, the lever *I*, which is operated by a cam on the ram, moves from the position illustrated until the center-line of the lever is in the position shown at I_1. The lever *I* moves the slide *K* through link *J*, and the slide *K* has a transfer slide *L* secured

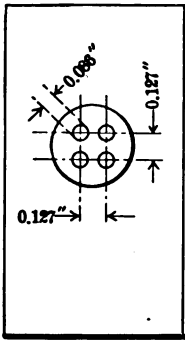


Fig. 6. Finished Button Back

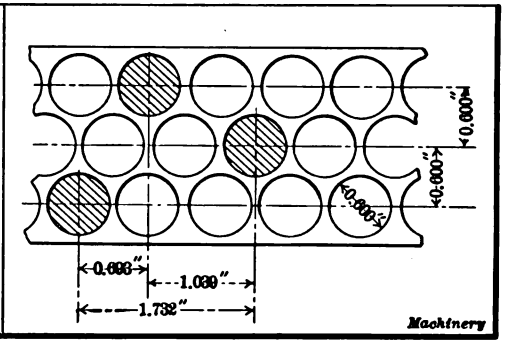


Fig. 7. Ribbon Stock showing Arrangement of Punches

to it, in which there are three holes for transferring the blanks to the piercing punch and die.

Before the work is blanked out the transfer slide has reached its extreme left-hand position, and after the blanking operation is completed the spring plungers *C* push the blanks down into the holes in the transfer slide. When the ram starts upon its return stroke the transfer slide moves to the right and delivers the blanks to the piercing die. The transfer slide *L* is held to the cast-iron slide *K* by means of the spring *M;* this spring will allow the transfer slide to remain stationary, regardless of the movement of the slide *K*, so that the mechanism will not be wrecked in event of any obstruction being met.

After the blanks are transferred to the piercing punches they are pushed out of the holes in the transfer slide by means of fingers *N* which act on each blank; these fingers are held down by the tension of springs *O*. Referring to this part of the illustration it will be seen that *P* is the punch stripper plate and *Q* one of the piercing dies. These three piercing dies have a three-degree taper on the sides and are forced into the machine steel die block *R*. After the blanks have been delivered to the piercing die the ram descends and pierces the

four holes, the scrap dropping down through the knock-out tube *S*. When the slide starts on its return stroke the knock-out *T* lifts the tube *S*, which, in turn, forces up the three pins *U*. These three pins raise the die stripper *V* so that the blanks are on the same level as the bottom of the transfer slide, and when the latter comes forward with a fresh supply of blanks it pushes the pierced blanks off onto the side of the press. The height to which the stripper *V* can be raised is limited by the stop *W* screwed onto the die block. The knock-out tube *S* is returned to its original position by the tension of the small coiled spring which is carried in a socket at its upper end, and the stripper *V* is returned by the tension of the springs *O* acting on fingers *N*.

The construction of the piercing punch is worthy of more than passing consideration. The steel castings *X* for the punch-holders are carried in stock, for these castings constitute the punch-holders used for producing a large variety of work. The punch-holders *X* carry the tool steel pins *Y*, which are not hardened. These pins are drilled to receive the four drill rod piercing punches *Z;* the upper ends of these drill rod punches are slightly upset to prevent them from dropping out of *Y*. A hardened tool steel plug A_1, is held in place on top of the four drill rod punches *Z* by means of the case-hardened set-screw and check-nut. In event of one of the piercing punches breaking, it is merely necessary to cut off a piece of the drill rod, upset it on one end, then harden it and place it in position in *Y*. Just enough pressure is put on the set-screw to hold the drill rod punches *Z* in place, but not enough to push *Y* out of place.

The factory in which this punch and die is used manufactures a large variety of button blanks which are supplied to outside firms, in addition to being used by the manufacturer. In many cases it is possible to use the same set of tools for several different styles of button backs, as a slight difference in the outside diameter of the blank will not waste enough stock to justify the expense involved in producing a new set of tools for this particular class of work.

Tools for Perforating Cylindrical Work

Very little has been written about the dies used for perforating the sides of cylindrical work. The punches and dies used for this purpose are similar to blanking punches and dies, except for the modifications necessary owing to the fact that the metal which passes over the face of the perforating die is circular in form instead of being flat as with a blanking die. Circular perforating tools are used in connection with this class of work because the nature of the work is such that it cannot, on account of both commercial and mechanical considerations, be carried out in any other way.

In Fig. 8 is shown a set of perforating tools together with a perforating attachment set up in a Bliss press ready for perforating a shell similar to the one shown in Fig. 10. The shell is first slipped over the die-holder (Fig. 11) in such a manner as to allow the elongated slot *A* in the bottom of the shell to engage with the pro-

jecting tongue of the driving arbor. The press is then tripped and the punches, at the first stroke of the press, cut out two of the irregular shaped perforations *B* in the shell. On the upward stroke of the press, a pawl *A*, Fig. 8, by the aid of a ratchet *B*, ratchet shaft *C* and the bevel gears, revolves the driving arbor, which rotates the shell a part of a turn. As the slot in the bottom of the shell is engaged with the tongue of the driving arbor, the shell is indexed with the arbor before the punch descends again. These operations are con-

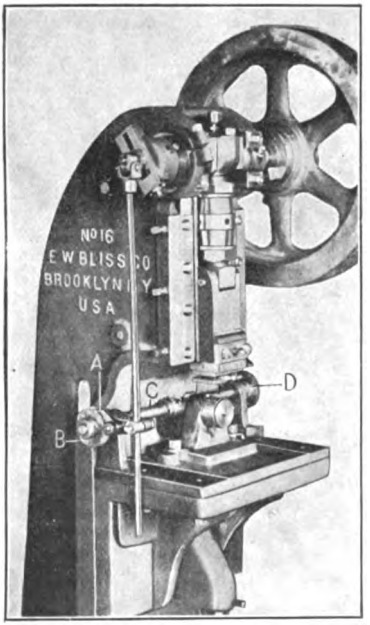


Fig. 8. Bliss Press with Attachment for Perforating Shell shown in Fig. 10

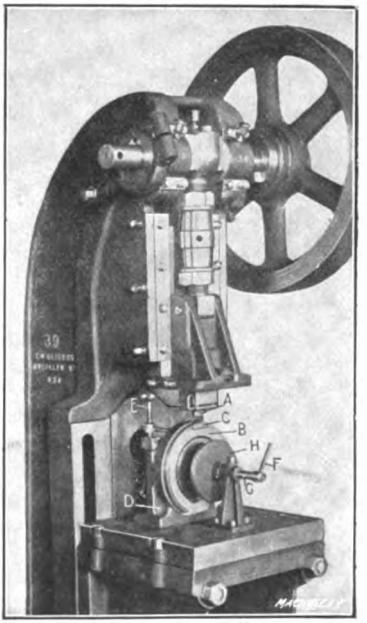


Fig. 9. Perforating Attachment with Special Device for Holding Shell in Place

tinued until the press, in this case, has made fourteen continuous strokes, when it is automatically stopped and the perforated shell removed. The stopping of the press is effected by cam *D*, which automatically releases the driving clutch when the required number of strokes has been made. The construction of the tools and the manner in which they are made will be treated later.

In Fig. 12 is shown another set of perforating tools for perforating the gallery fence of a lamp burner shown in Fig. 13. The gallery fence of a lamp or gas burner holds the lamp chimney or globe in place by the spring pressure exerted by the perforated part. The metal must be hard in order to impart the required spring pressure and is, therefore, on the better grade of burners, burnished before perforating, which not only hardens and toughens the metal, but also produces a brilliant finish. On the cheaper grade of burners, the

shells from which the gallery fences are made are passed through an extra re-drawing operation, the shells not being annealed, but left hard. The difference in the diameter of the shell before and after re-drawing is about 1/32 inch, while the difference in the thickness of the metal is about 0.0005 inch. This treatment of the metal not only imparts the required springiness, but also makes the perforating operations easier, as hard metal is more readily perforated than soft.

The tools used for perforating the gallery fence shown in Fig. 13 are somewhat different in construction from those shown in Fig. 8. The ratchet *C*, Fig. 12, is keyed to the driving arbor, and when the tools are set up in the press they are set with the face of the die-holder turned towards the right, instead of facing the operator. The perforating operation, however, is similar to the one already described. The effect of the successive strokes of the press is indicated in Fig.

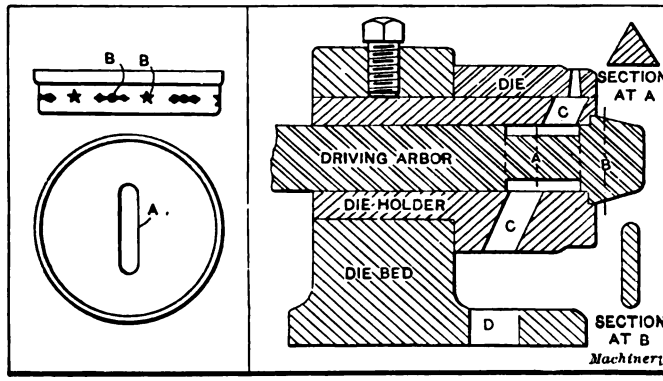


Fig. 10. Example of Shell to be perforated

Fig. 11. Section of Die Bed, Holder and Die for Perforating Shell shown in Fig. 10

13. At the first stroke of the press, the four shaded areas at *F* are punched out. At *G* can be seen the appearance of the shell after the second stroke. In order that no burr or fin may be left on the top points of the scallops, the die is made so that the punch will cut a trifle past the center of the point as shown at *H*. The shell is rotated towards the left by the driving arbor, and a simple holding device, not shown in the illustration, is used for holding the shell in place on the arbor.

An attachment for holding work in place while it is being perforated is shown in Fig. 9. This attachment is used in connection with the tools for perforating the sides of large narrow rings. The tool equipment consists of a perforating punch *A*, and a large die-holder *B* for holding the dovetailed perforating die *C*. The die-holder is held in die-bed *D*. The perforating attachment, which rotates the shell, is placed directly back of the die-bed and is operated by the adjustable connection *E*, fastened to the gate of the press. After the ring is slipped over the die-holder, handle *F* is given part of a turn to the right which, by means of the spiral grooved arbor *G*, causes

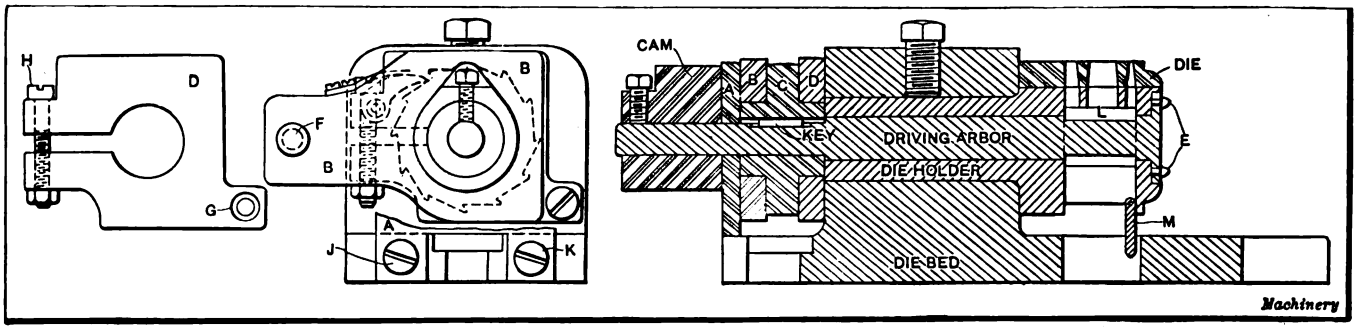


Fig. 12. Section of Die Bed, Holder and Arbor for Perforating Shell shown in Fig. 13

the circular disk *H* to come in contact with the ring, thus holding it in place. This circular disk rotates with the ring and is attached to arbor *G* by a pin in the hub of the disk which engages with a circular groove in the arbor.

Construction of Perforating Tools

In Fig. 14 the perforating die for the shell in Fig. 10 is shown held in a dovetail channel in the die-holder. The die-holder is preferably made of a cheap grade of tool steel, and is held in the die-bed as shown in Fig. 11. The dovetail method for holding the dies is probably the best, and is the one most commonly used. The sides of the dies are beveled at an angle of from 5 to 10 degrees. For work such as shown in Fig. 10, the die is tapered lengthwise on one side with a taper of about 1 degree, and is driven into the die-holder from the back and left flush with the shoulder of the holder, so that when in position, the die-bed prevents it from shifting back. When it is possible to do so, a pin or a fillister-head screw may be used to prevent the die from shifting endwise. The shape of the shell and the design to be perforated sometimes governs the taper of the sides of the die. This, for example, is the case where shells such as shown in Figs. 16 and 18 are perforated, when a greater angle than 1 degree must be used on account of the irregular shape of the die-holder and dies.

The longitudinal cross-section of the die-bed, die-holder and driving arbor used for the shell in Fig. 10 is shown in Fig. 11. Section *A* shows how the arbor is milled at the neck *A* in order to allow the scrap punchings to drop through. A section of the tongue of the arbor which

engages the slot in the end of the shell, by means of which it is rotated, is shown at *B*. This tongue is tapered as shown, to facilitate the putting on and taking off of the work. A scrap escape hole *C* is drilled in the die-holder at an angle as shown, so as to prevent the scrap punchings from coming in contact with the shell while it is rotated around the die. An escape hole drilled in this manner can only be used on short shells and when the scrap punchings are small, or, if they are large, when they are few in number. Hole *D* in the die-bed permits the scrap punchings to readily fall out of the way.

The construction of the tools shown in Fig. 12 is somewhat different. Two small pins *E*, which are used in the face of the driving

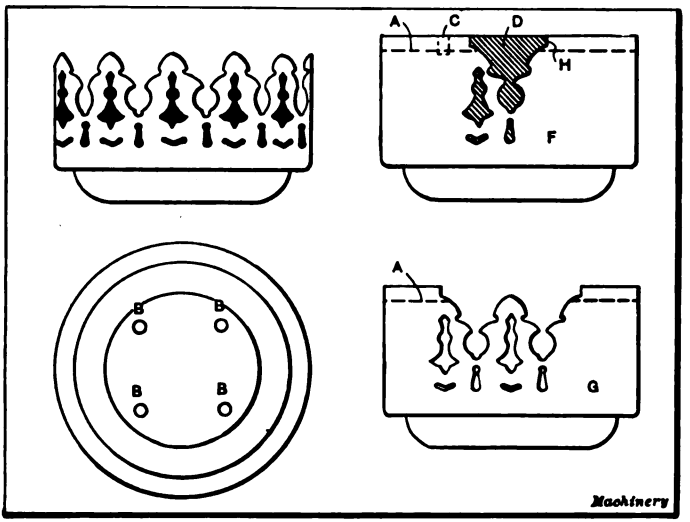


Fig. 13. Shell to be perforated, showing Successive Operations

arbor, act as driving pins for rotating the shell. These enter into pierced holes in the bottom of the shell as shown at *B*, Fig. 13. The pawl which operates the indexing ratchet is fastened to part *B* in Fig. 12, which is made to fit the shoulder of the ratchet and works back and forth in order to provide for the required indexing. The back-and-forth motion is imparted to *B* by fastening a handle *F* to an adjustable connecting-rod which is, in turn, fastened to the crankshaft of the press. Part *D* is a brass friction which takes up the backlash of the driving arbor. This friction is fastened to the die-bed by a screw at *G*. The hole in the center of the friction fits the shoulder on one end of the ratchet. The brake or friction effect is applied by screw *H*. Part *A* acts as a steadyrest for the driving arbor, and is fastened to the die-bed by screws *J* and *K*.

The cam fastened to the end of the driving arbor causes the press to stop automatically by coming in contact with a lever connected to the driving clutch. The driving arbor is relieved at *L* to prevent the congestion of the scrap punchings. The hole for the driving arbor in

the die-holder is also recessed at this place in order to give the scrap punchings, which, in this case, are rather large, ample room to pass the arbor. When the device is in operation, a shutter *M* closes up the bottom of the scrap escape hole in the die-holder. When the shell is slipped over the latter, the shutter is forced up and thus acts as a trap, preventing the punchings from dropping through into the inside of the shell. If the punchings were allowed to drop through and should cling to the perforated holes, they would cause the shell to jam and prevent it from rotating. When the perforated shell is removed from the die-holder, the shutter drops down of its own accord, thereby allowing the scrap punchings to drop out.

Perforating Shells of Tapered and Irregular Shapes

In perforating shells of tapered and irregular shapes the same general methods of procedure as already described are used, with the

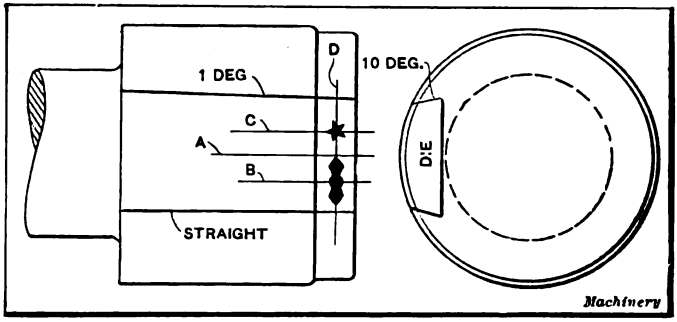


Fig. 14. Die in Position in Die Holder

exception that the die-holder is held in the die-bed at an angle of 5 to 70 degrees or more with the bottom of the die-bed, the angle depending on the shape of the shell and the perforations to be made in it. In Fig. 15 is shown a die, die-holder and die-bed for work of this kind. The angle at which the die-holder is set should be such that if the outer ends of the two extreme holes in the perforating die are connected by a straight line, this line would be parallel with the bottom of the die-bed, as indicated in Fig. 16, where the points *A* and *B* are on the line which should be parallel with the base of the die-bed.

In Fig. 15 may also be seen the shell which is perforated by the die. The shell is rotated around the die by the tongue of the driving arbor engaging in an elongated hole in the bottom of the shell. The arbor is relieved at *A* in the usual manner to allow the scrap punchings to escape. No shutter is used, as the open end of the shell does not come near the scrap escape hole. The ratchet *B* which is operated by a pawl, not shown, is keyed to the driving arbor, while the friction used for controlling the backlash bears upon the shoulder of the ratchet as indicated. This shell has two rows of perforated holes, fifty-two holes in each row. Eight holes at a time are cut, or four holes in each row. The reason that four holes in each row are cut at each stroke, in-

stead of five, six or eight, is, in the first place, that the number of holes cut at each stroke of the press must be such that the total number of holes in each row is a multiple of it. In the second place it is not possible to get good results if the end punches are too far away from the center of the work, as these punches would strike a glancing blow. These holes would be somewhat elongated and "burry" instead of being clean, round and free from burrs. In this case, four holes in each row is as much as is practicable. Of course, if the holes are small in diameter and close together, a greater number can be cut at one time than when they are larger and further apart. If the diameter of the shells is large, a greater number of holes can also be cut at one time than with shells of smaller diameter, other conditions being equal.

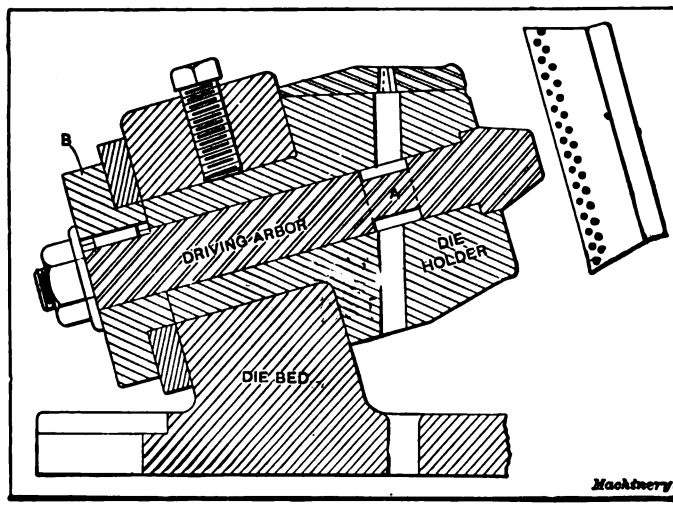


Fig. 15. Die, Die Bed and Holder for a Tapered Shell

In Fig. 17 is shown another set of perforating tools set up in a Bliss press. These are used for perforating the sides of the tube shown at *A* with a series of rows of small holes. These tools are of a somewhat different type from those already described. No driving arbor is used, but the shells are rotated direct from the ratchet which is placed in front of the die-bed. There may be several reasons for using this construction: When the bottom of the shell is to be left intact, no driving arbor can be used; sometimes the required shape of the shell is such as to prevent the use of a driving arbor; when the scrap punchings are so large and no numerous as to prevent them from dropping through if a driving arbor is used, or when that part of the shell that is to be perforated is very small in diameter, it may also be impossible to use a driving arbor.

Referring again to Fig. 17, it will be seen that another set of perforating tools similar to the one set up in the press is shown to the

left. This is used for perforating the shell shown at *B*. The ratchet and pawl are shown at *C* and *D*. The latter is fastened to the dovetail slide *E* in the die-bed *F*. This slide is operated by the gate of the press by connection *G*. The holding-on attachment consists of a slotted stud in the die-bed to which a swinging arm is pinned. A circular disk which revolves with the work is fastened to this arm, as is also the small handle directly in front of the attachment. This handle is used by the operator to swing the arm up and out of the way preparatory to removing the perforated shell from the die-holder.

A method commonly used in connection with perforating tools for rotating the shell to be perforated is the dog-notch method. A dog *C*, Fig. 16, is fastened to the ratchet by screws or dowel pins. The end of this dog fits a notch *D* in the shell, called the "dog-notch." The

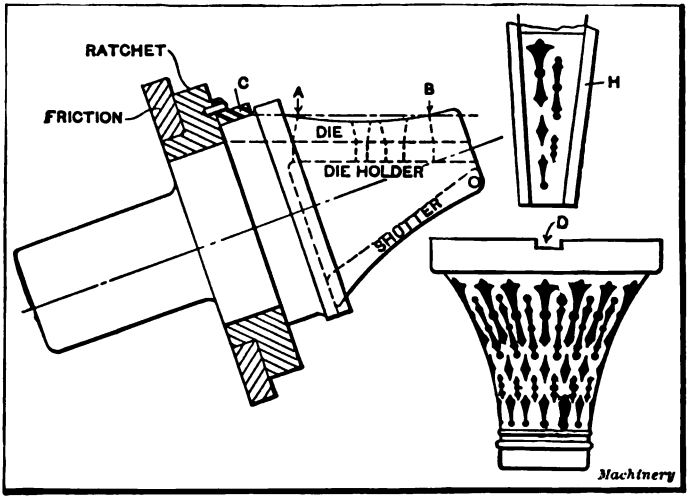


Fig. 16. Die and Holder for Perforating Shell shown to the Right

shell is slipped over the die-holder in such a manner as to cause the dog-notch in the shell to engage with the dog on the ratchet. In this way the ratchet can index the shell directly around the die-holder.

There are also a number of other methods used for rotating shells to be perforated. Besides those already described, one may make use of an irregular shaped hole in the bottom of the shell in connection with the driving arbor. Sometimes an irregular shaped hole is required in the bottom of the shell, and in such a case the tongue of the driving arbor may be made to fit this hole, which affords a good driving means. Sometimes use is made of a coaster brake device fastened to the ratchet. The tools used in connection with this device are similar to those already described, having the ratchet in the front of the die-bed, as shown in Fig. 16, with the exception that instead of using a dog, a device working on the principle of a coaster brake, such as is used on an ordinary bicycle, is fastened to the ratchet.

With this device, no notch in the shell is required, as the open end of the shell is simply slipped into this device and given a part of a turn, causing it to be tightly gripped. The press is then tripped and the shell rotated around the die in the usual manner.

In cases where a dog-notch is used and where there is a tendency on the part of the shell to slip in between the dog and the die-holder, which would prevent the shell from being properly rotated, the die-holder is turned down as shown in Fig. 16, and the dog is made to just clear the holder. This prevents the shell from slipping in under the dog.

The perforating die shown at *H* is held in the die-holder in the usual way, and is tapered lengthwise at a suitable angle as indicated.

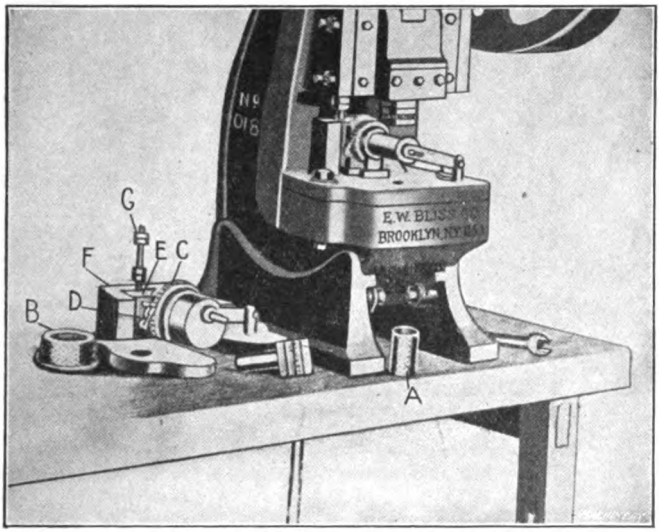


Fig. 17. Tools for Perforating Special Cylindrical Shells

In order to afford a support for the die when in use, the bottom of the dovetail channel upon which the die rests is worked out so as to conform to some extent to the shape of the bottom of the die. This is done on dies where the holes are close together, so as to support the narrow bridges that separate the irregular shaped holes in the die. The best way to do this work is to first work out an open space under the dovetail channel. This space is used for holding the scrap punchings that are prevented from dropping through by a shutter. In working out this space enough stock is left under the dovetail channel to support the die properly, as indicated in Figs. 16 and 18, after which the openings through which the scrap punchings from the die drop are worked out. The shutter which is shown closed in Figs. 16 and 18 swings open on the shutter pin as soon as the perforated shell is removed from the die-holder.

The construction of the tools in Fig. 18 is similar to that of those

just described. At the right is a plan of the die, showing the manner in which the die is tapered lengthwise, which in this case is six degrees on each side. When the tools shown in Figs. 16 and 18 are in operation, two rows of holes are cut at every stroke of the press until the shell has completely rotated around the die and all the required rows of holes have been punched out. No device is used with these tools for holding the shells in place while they are rotating around the die, because the position of the die-holder in the die-bed makes it easy for the operator to keep the shell in place.

It sometimes happens that a perforated shell of the general type shown in Fig. 13 is required, with the exception that the bottom is left intact and therefore cannot be used in connection with a driving

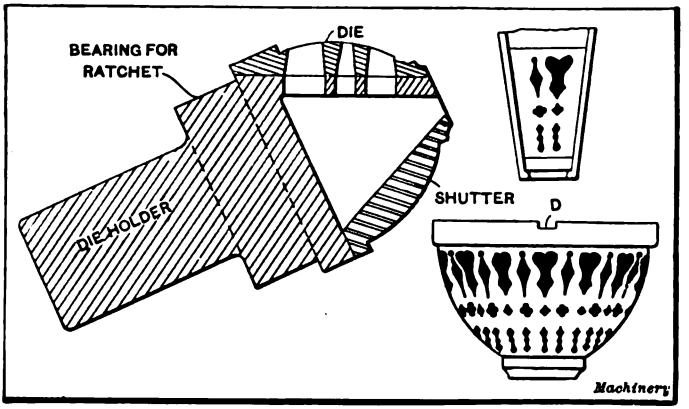


Fig. 18. Die and Holder for Perforating Shell shown

arbor for rotating the shell. In such a case, the shell is dog-notched and rotated in the manner already described, with the exception that the locating of the dog on the ratchet preparatory to perforating the shell forms an important part in the successful operation of the tools. The reason for this is that when cutting out the scallops of the shell, the dog-notch *C*, Fig. 13, which is used for rotating the shell must necessarily be cut away from the shell, and must, therefore, be placed in such a position that it will come in the center of the large scrap punching which will be cut out at the last stroke of the press, completing the operation. If the shaded portion shown at *D* is the punching resulting from the first stroke of the press, and if the blank is rotating from right to left, then the dog-notch must be located at *C*, central between the two scallops completed by the last stroke of the press, after the whole shell has been perforated.

In order to prevent the punch *A*, shown in the upper right hand corner of Fig. 19, which cuts out the scrap punchings *D*, Fig. 13, from coming in contact with the dog, a short slot is milled in the center of the face of the punch at the back end near the ratchet, so that the punch will clear the dog when that part of the shell containing the dog-notch is cut out.

Lay-out of a Perforating Die

Preparatory to laying out the die shown in Fig. 14, the die-blank is carefully fitted to the dovetail channel in the die-holder, after which it is turned up in the lathe in place and highly polished. It is then removed from the die-holder and blued by heating, and again driven into the die-holder, after which it is ready to be laid out. The die-holder is then mounted in the milling machine, the index head in this case being set for twenty-eight divisions, as there are fourteen per-

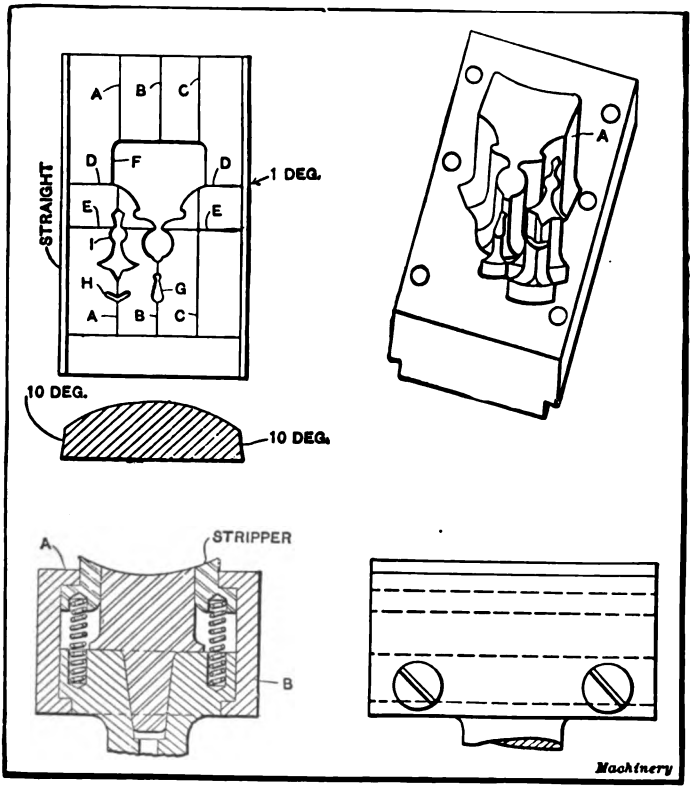


Fig. 19. Perforating Punch and Die

forated holes of one design and fourteen of another. With a surface gage and by aid of the index head, the center lines *B* and *C* are scribed. Line *A* is merely drawn to show the center of the die, and the center of each one of the holes in the die should be an equal distance from this line. Center line *D* is next scribed the required distance from and parallel with the face of the die-holder.

In laying out the hole on the center line *B* a small circle of the exact diameter of the circular opening in the center is first scribed. The diamond-shaped ends are next laid out and scribed. The star-

shaped hole on the center line *C* is laid out from a master punch which conforms to the required size and shape. In cases where the required number of shells to be perforated does not warrant the making of a master punch, the dies are laid out from the star-shaped punch that is used in connection with the die.

In working out the die, the central hole from which the star design is made is first drilled and taper-reamed from the back to the size of the teat on the master punch, which is equal to the diameter of the circle passing through the bottom of the grooves in the star. The teat of the master punch is then entered into the die and the punch set and clamped to the die so that a point of the star is on line *C*. The outline of the punch is then scribed on the face of the die, after which the die is worked out and fitted to the punch. In order to facilitate matters, the punch is used as a broach after the die is filed to shape. In working out the other hole in the die, on line *B*, a hole is first drilled and taper-reamed from the back for the circular opening in the center. Two holes are drilled and reamed in the center of the diamond-shaped ends. The surplus stock between the drilled holes is then removed and the hole filed to the desired shape.

There are two ways in which a die such as that shown in the upper left-hand corner of Fig. 19 may be laid out. One is to lay out the die on a milling machine in a manner similar to that already described. The other, which is most commonly used, is to lay out the die by scribing the design on its face from a master shell slipped over the die-holder which has the shape to be perforated worked out upon it.

The master shell itself is laid out as follows: The shell is fastened to the die-holder by a few drops of soft solder to prevent it from moving. The die-holder is then mounted in the milling machine. The index head in this case is set for twenty-four divisions. In Fig. 19 is shown the laying-out of the die, but the same method applies to the shell. With a surface gage used in connection with the index head, the lines *A*, *B*, and *C* are scribed on the shell. Lines *A* and *C* represent the centers of two adjoining scallops, and line *A* is also the center for the two holes *I* and *H*, while line *B* is exactly in the center between two scallops and constitutes the center line for hole *G*. The lines *E* and *D* are next scribed on the shell, the former representing the height of the ears of the projecting scallops, while the latter shows the height at which the lower curved portions of the pointed scallops converge. After these construction lines are scribed on the shell, the design is readily laid out. The shape of the design is then worked out by drilling and the surplus stock is removed by means of a jewelry saw. The shell is then filed to the desired shape and when completed should be a duplicate of the portion cut out by the first stroke of the press, as shown at *F* in Fig. 13. In filing out a design, care should be taken to file out all the holes central with the center lines *A*, *B* and *C*, and also parallel with a plane passed at right angles to the center of the design, through the shell, in order that the holes may be at their exact required position on the inside of the shell.

It will be noted in Fig. 19 that the large hole *F* in the die is extended past the line *D;* this is done in order to make sure that the large scrap punching *D*, Fig. 13, will be completely cut from the shell. This is especially necessary when the shells vary in length. The dotted line *A*, Fig. 13, is drawn so as to more clearly show the length of the twelve pointed scallops, and their relation to the top of the shell.

In drilling and working out the surplus stock in the die Fig. 19, the same general methods that are used for working out an irregularly shaped blanking die are used. First, remove as much of the surplus stock as possible by drilling. When drilling out the surplus

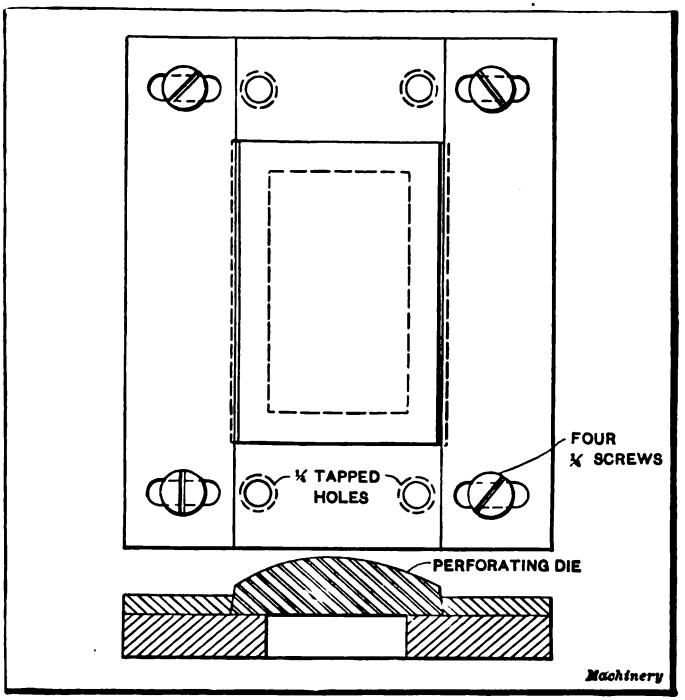


Fig. 20. Device for Holding Perforating Dies while Filing

stock in the hole *F*, the smaller of the two circular openings between the scallops is first drilled out and taper-reamed from the back to the finish size. After this, the hole is plugged with a small taper pin that is filed to fit it, and the large hole is drilled and taper-bored in a lathe. The round corners at the opposite end of the hole are then drilled out. These corners are left circular in order to add to the strength of the die and to prevent cracking of the die in hardening. The remainder of the hole is drilled and worked out in the usual way. In working out the small holes *G* and *H*, the opposite ends are first drilled and taper-reamed to the finish size, after which other holes are drilled and reamed and the surplus stock is removed with

a small broach or jewelry saw preparatory to filing out the die. Hole *I* is drilled out and the surplus stock removed in a similar manner.

Filing Out the Die Shape

A die used for perforating the sides of cylindrical work is rather awkward to hold, either in the vise or in die-clamps while being filed out, owing to the fact that the face of the die is circular in shape and the sides are dovetailed. For this reason, a die-holding fixture, shown in Fig. 20, is used to hold the die in the vise, die-clamp, or filing machine while it is being filed out. The device shown is adjustable to accommodate various widths of dies.

The most essential points to be remembered when filing out a perforating die are: Use a coarse file for the rough filing and finish with a smooth one. Take care to have the clearance filed straight in order to prevent the congestion of scrap punchings in the die; perforating dies as a rule are not very strong and are often cracked and broken because of neglect on this point. The clearance should not be filed over 1½ degree, in order to make the die as strong as possible; in cases where the holes in the dies are close together even less clearance is necessary, and a very narrow wall that separates two holes is filed almost straight on each side, with just enough of a taper to clear. Care must be taken when filing to prevent the back or the sides of the file from running into the finished part of the die.

Making the Punch for a Perforating Die

The punch used with the die shown in Fig. 14 is comparatively simple in its construction. It consists of the usual form of punch-holder into which the two perforating punches are driven. The star-shaped punch, after it is fitted to the die and hardened, is driven into the punch-holder in such a position that when it is entered into the die the sides of the punch-holder will be in a straight line and parallel with the die-bed. The tools are then set up in a hand or foot press so that the die and star punch are in proper alignment with each other. The foot treadle of the press is then disconnected from the gate so that the gate which holds the punch-holder in place can be withdrawn from the press without disturbing the punch-holder or the ways upon which the gate slides. The other punch, in its unfinished state, is then driven into the punch-holder and the face is coated with a 1/16-inch thickness of soft solder. The gate of the press is then slipped back into place and the impression of the outline of the die is transferred to the solder on the face of the punch. The punch-holder is then removed from the press and the punch driven out and milled to conform to the soft solder outline of the die, after which the punch-holder is put back into the press, care being taken to see that the star-shaped punch is in proper alignment with the die. The milled punch is then put back in place and gradually sheared and fitted to the die. Each time after the punch has been lightly sheared into the die, the fins and surplus stock are removed and the punch is again entered and sheared a trifle deeper, until it enters the die at least ¼ inch.

The hand or foot press is very convenient to use when fitting perforating punches to their dies, because the construction of the press makes it possible to handle the gate conveniently and to keep the punches in proper alignment with the die.

In making perforating punches such as shown in the upper right-hand corner of Fig. 19, the punch-holder is first machined to the desired shape and size, after which the taper hole for the shank of punch *A* is reamed. The shank of the punch is then turned and fitted to the punch-holder and driven into place. The face of the punch is made to conform to the outside diameter of the shell and is then clamped to the face of the die and the outline scribed on it, after which it is milled to shape and sheared and fitted to the die. Before scribing the outline of the die on the face of the punch, care must be taken to see that the punch is set in the proper relation with the die, so that when the finished tools are set up in the press, there will be no necessity for elongating or widening the slots in the die-bed used for clamping the die to the bed of the press, due to the punch not being laid out central with the die.

After the first punch *A* has been fitted to the die, the holes for the other three punches are laid out so that the cutting part of the punches will be as nearly central with the shanks as possible. Holes are then drilled and reamed for the shanks, and when this is done punch *A* is hardened. The reason that this punch is hardened before the other punches are fitted to the die is that if the punches were all sheared and fitted together and then punch *A* should spring in hardening, it would cause great difficulties in again bringing the punches into proper alignment with the die. After punch *A* has been hardened and driven back into the punch-holder, the shanks of the other three punches are turned up and fitted to the respective holes into which they are afterwards driven. The shanks of these punches may be made either straight or tapered, but should be a good driving fit and should have shoulders bearing against the punch-holder.

Before the punches are driven into place, the die and punch *A* are set up in the foot press and properly aligned with each other. The gate of the press is then withdrawn, the three punches are driven into place, and the faces coated with soft solder. The gate of the press is then slipped back into place and the outline of the die transferred to the punches, after which they are driven out and milled separately in the milling machine. Sometimes the punches cannot be driven out from the back of the punch-holder, because if the holes for these punches were drilled through they would run into and weaken the shank of the holder. In such cases holes are drilled from the side to meet the shank holes, in order to allow a taper drift to be used for starting the punch so that it can be removed.

After the punches have been milled, they are driven back into the punch-holder and are sheared and fitted into the die, as previously described. The punches, of course, are lined up perfectly with the die so as to enter into their respective holes as one single punch.

After the punches are hardened they are sharpened by holding the punch-holder in a special grinding fixture and drawing the punches back and forth across the face of a wheel of about the same diameter as the shell to be perforated. The bases of the punches are strengthened by milling the punches so that there is a liberal fillet between the shoulder of each punch and the milled-out shape. This also tends to prevent distortion in hardening.

The Stripper

The stripper serves three purposes: It strips the metal from the punch; it supports the small punches by preventing them from springing; and it tends to keep the perforated shell in shape by preventing

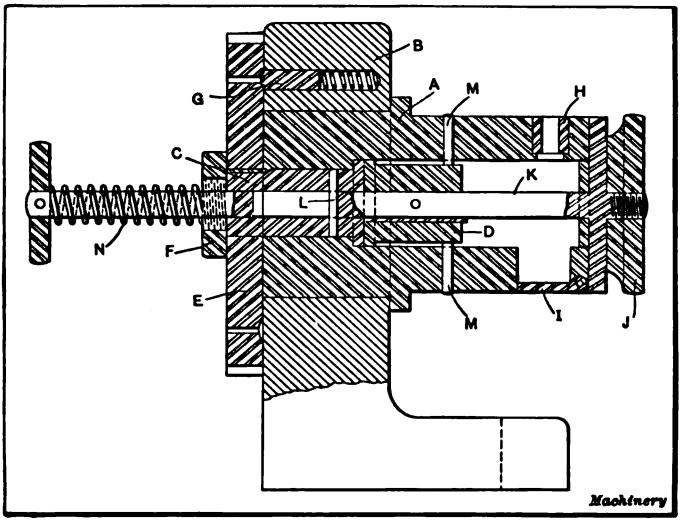


Fig. 21. Type of Die used for the Spiral Perforating Operation

it from bending or becoming "kinked up." The commonly used stripper construction is shown by the lower view, Fig. 19. The face of the stripper conforms to the outside diameter of the shell. It is drilled and worked out so that it is a sliding fit on the punches. The shoulder part of the stripper bears against the bottom lugs of the side pieces *A* and *B*, which are fastened to the punch-holder and prevent the stripper from being forced off the punch. Six spiral springs exert the required pressure on the stripper. When setting up the tools in the press, the stripper is forced back about ⅛ inch and two pieces of, say, No. 31 drill rod are placed between the stripper and the bottom lugs of the side pieces, which keeps the stripper out of the way while the punch and die are aligned with each other.

Perforating dies of the type described are sharpened on universal grinding machines. Owing to frequent sharpening it is sometimes necessary to raise them slightly by putting shims of sheet steel under

the dies. These shims are drilled and filed out to conform to the holes in the dies, in order that the scrap punchings may drop through.

Spiral Perforating

The die shown in Fig. 21 was designed to perforate shells similar to the one shown in Fig. 22, having holes extending along a spiral. It will be seen that the tool consists of a die-holder *A*, which is carried by the die bed *B*. This die-holder is counterbored to receive the mandrel *C* and cam *D*, which controls the movement of the shell to obtain the desired location for the holes. An index ratchet *E* is keyed to the left-hand end of the mandrel and held in position by a nut *F* which holds it against the die bed. This ratchet is operated by a pawl carried by the ram of the press. In order to take up any backlash and secure accurate indexing, a spring pin *G* is provided. This pin enters counterbored holes in the ratchet, which are properly spaced to locate the holes in the desired positions in the shell; when the ratchet is moved on to the next station, the pin is forced back into the die bed and then enters the next hole in the ratchet.

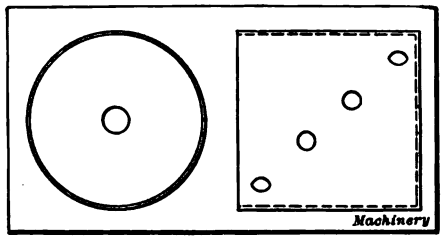


Fig. 22. Shell Having Spiral Perforations

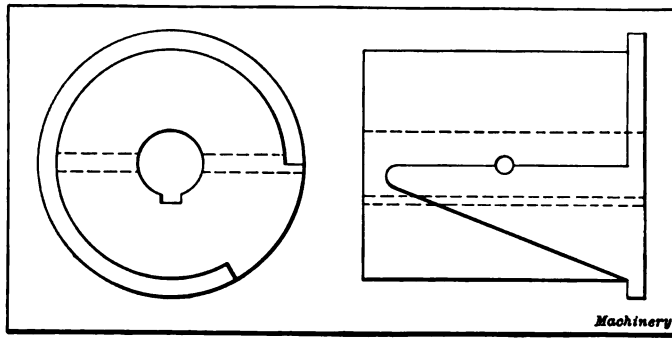


Fig. 23. Cam used on Spiral Perforating Die

The piercing die *H* is driven into the die-holder and the piercings are held inside the drum until all of the holes have been punched, by means of a trap door *I*. The shell is held in position by nut *J* carried at the right-hand end of the shaft *K*. Cam *D* which controls the movement of the shell is secured to the shaft *K* by means of a key and pin. (This cam is shown in detail in Fig. 23.) Four pins *M* extend into the bore of the die-holder and these pins are engaged successively by the cam *D*. The left-hand hole of a series is first pierced; the ratchet then rotates the shell and the action of the cam moves it to the right. The indexing is effected as previously described, one hole being pierced

at each station. After the four holes on one spiral have been pierced and the ratchet starts to index for the next hole, the pin *M* slips over the point of the cam and the tension of the spring *N* then returns the cam and the work to the extreme left where the cam is engaged by the next one of the pins *M*. This process is repeated four times to complete piercing the holes on the four spirals in the shell. The longitudinal movement of the shell is limited by the pin *L* which fits in a slot in the shaft *K*. This die proved very satisfactory for this perforating operation.

Press Tools for Clipping and Piercing Brass Shells

Several interesting forms of press tools for performing clipping and piercing operations on brass shells are described in the following. Fig. 24 shows the shell *A* which is to be clipped along the dotted line, and at *B* and *C* two views of the completed shell are shown. The die used for this clipping operation is illustrated in Fig. 25. The die *A*, over which the shell slips is a hardened steel collar which is made to fit the shell accurately. This die is driven onto the stud *B* and held in place by means of the dowel pin *C*. The stud B is a press fit in the

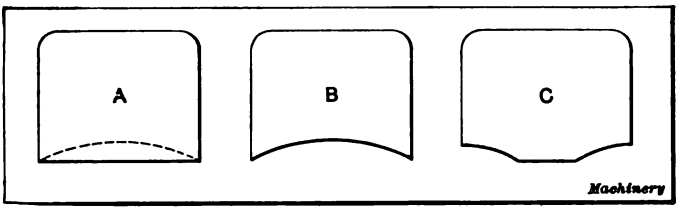


Fig. 24. Shell A to be clipped along Dotted Line, and Two Views of Clipped Shell

die-bed and is prevented from turning by means of the key *D* which serves the additional purpose of locating the stud in the desired position.

The clipping punches *E* are mounted on two dovetailed slides in the die-bed. This construction will be readily understood by referring to the cross-sectional view of the die-bed along the line *X-X*. Allowance is made for any adjustment of the punches that may be necessary on account of grinding by the provision of elongated holes for the screws which secure the punches to the slides. In case any adjustment is made, a shim of sheet steel of the required thickness is placed between the back of the punch and the slide; this gives the punch a bearing on the slide and relieves the screws from the pressure of the cut. The punches are made to conform accurately to the cutting edge of the clipping die. The faces of the clipping punches conform to the circumference of the shell and the points *E* cut a little in advance of the remainder of the punch in order to insure having the shell clipped without leaving a fin or burr of any kind.

Operation of the Tools and Die-bed

In order to clip a shell with this set of tools, the work is placed over the die and the press is then tripped. The punch shown in Fig.

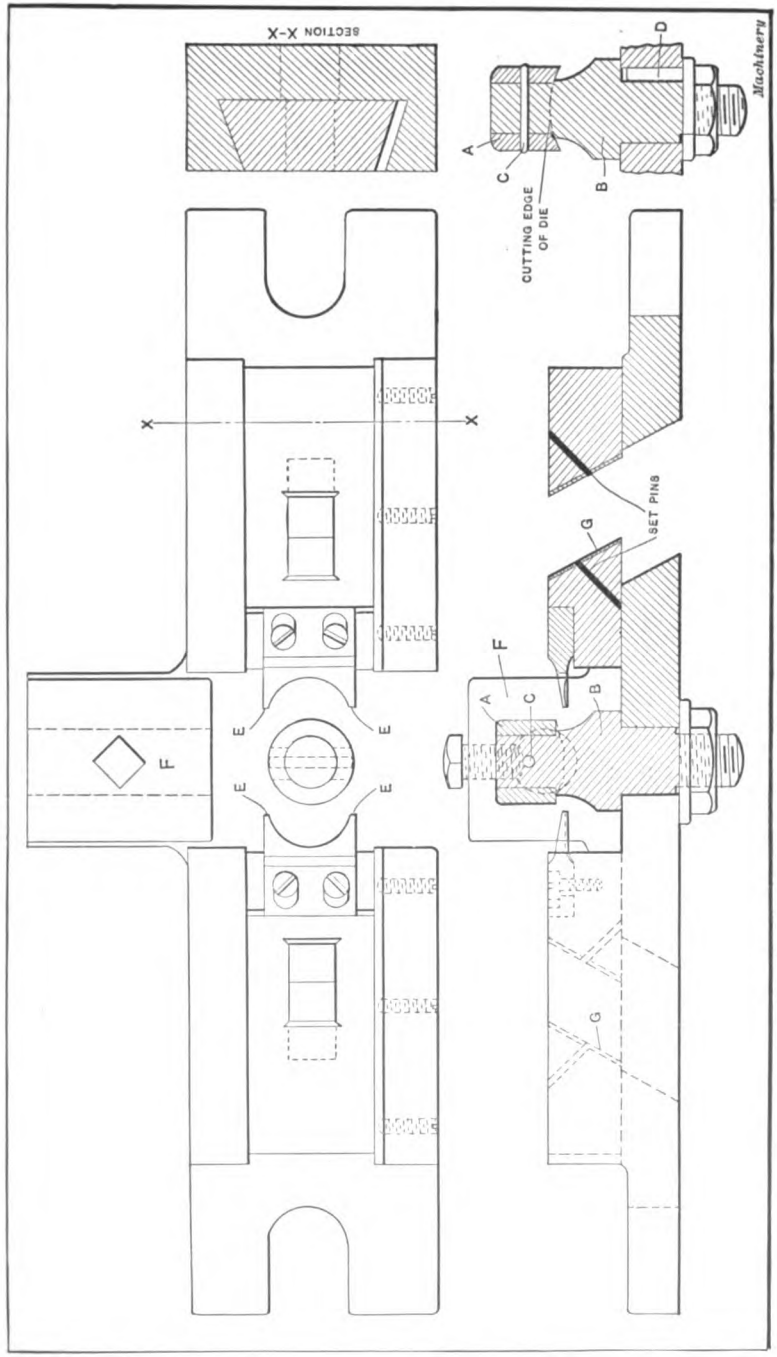


Fig. 25. Die-bed equipped with Tools for clipping Shell shown in Fig. 24

26 is held in the ram by means of the shank *A*. When the ram descends, the inner surfaces *B* of the arms which are inclined at 30 degrees, come in contact with the steel pads *G*, Fig. 25, in the slides that carry the clipping punches and move them in toward the die. This brings the clipping punches into action and causes the shell to be clipped. When the ram starts its return stroke, the outer surfaces *C* of the arms on the punch cause the slides which carry the clipping punches to be returned to their original positions. It will be obvious that this method of actuating the slides is positive in action and does away with the use of springs for returning the slides. It will be seen that the punch-holder *D*, shown in Fig. 26, has a small piercing punch *E* mounted in it. This piercing punch is used in an operation that

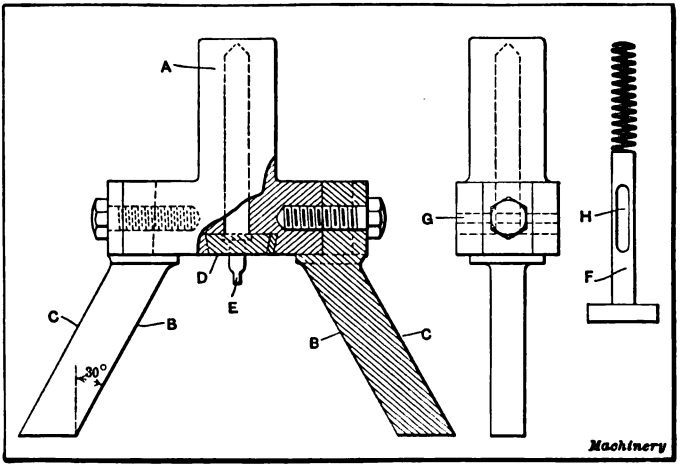


Fig. 26. Punch-holder with 30-degree Angle Arms to control the movement of the Slides

will be described later. When the tool is used for the clipping operation, the piercing punch *E* and the punch-holder *D* are removed from the punch and the "hold-down" *F* is mounted in their place. This hold-down is held in place by means of a pin *G* which fits in the slot *H*, the length of the slot being sufficient to allow the hold-down the necessary amount of movement. This hold-down moves a little ahead of the clipping punches and thus comes into contact with the top of the shell and holds it securely in place so that it cannot be raised off the die when the clipping punches begin to cut.

Construction of the Die-bed

The shells that are clipped or pierced on this die-bed are ordered in lots of not over 25,000. This fact made it desirable to make a die-bed that could be used for both clipping and piercing operations, and this advantage is obtained by the design shown in Fig. 25. This would not be of much advantage, however, if the work had been ordered in large quantities which would require the same set of tools to work day after day. In some cases, it was found desirable to provide

special slides for a given set of punches and the clipping punches shown in place on the die-bed in Fig. 25 are an example of this kind. When these punches are removed, the slides are taken off with them and the regular slides can then be put in place on the die-bed in order

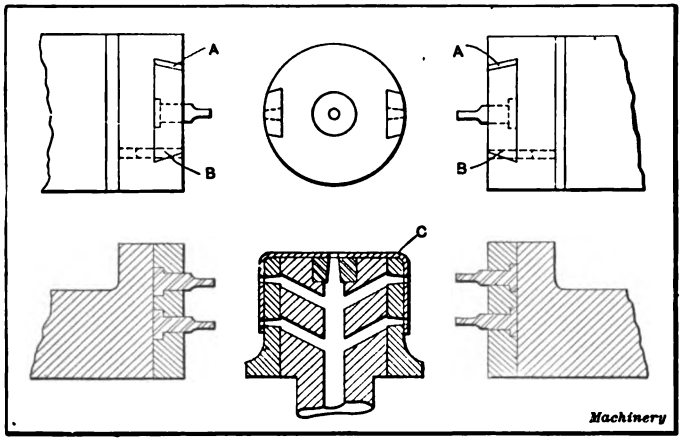


Fig. 27. Die set up for piercing Shell held in Vertical Position

to allow other tools to be set up. It will be seen that gibs are provided to enable any wear which may develop in the slides to be taken up.

The construction of the die-bed is such that shells can be held in

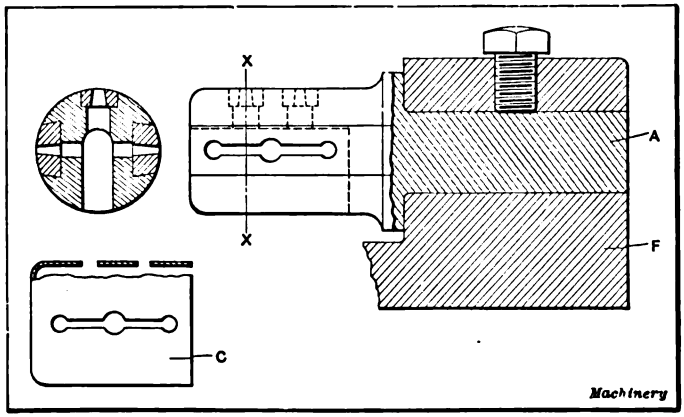


Fig. 28. Die set up for piercing Shell held in Horizontal Position

either a horizontal or vertical position. This will be better understood by referring to Figs. 27 and 28 which show shells mounted in the vertical and horizontal positions. The shell *C* which is shown in position on the die in Fig. 27, has five holes pierced in it. Two of these holes are pierced in either side of the shell by means of pierc-

ing punches carried in the slides of the die-bed, while the fifth hole is pierced in the top of the shell by means of the piercing punch *E*, which is shown in position in the punch-holder in Fig. 26. The piercing punches for working on the sides of the shell are mounted in regular slides of the die-bed shown in Fig. 25. Referring to the top view in Fig. 27, it will be seen that these punches are mounted in dovetail holders which are held in the desired position by means of keys *A*. The pins *B* locate the punches in their proper positions and are particularly convenient in obtaining the desired alignment when setting up the tools after they have been removed for sharpening.

Fig. 28 not only shows the construction of the piercing die for piercing the shell *C* (shown at the left-hand side of the illustration) but also illustrates the way in which the work is held in a horizontal position in the same die-bed that is used for holding work in a vertical position. Referring again to the illustration Fig. 25, it will be seen that the part *F* at the back of the die-bed has a hole in it to receive the shank *A* of the piercing die-holder which is held in place by means of a set-screw. The shell *C* which is pierced on this die could be pierced in a vertical position but this would necessitate a three-slide die-bed. With the method now in use, the slot at either side of the shell is pierced by punches carried in the slides of the die-bed and the two small holes at the top of the shell are pierced by two punches carried in the punch-holder mounted in the ram of the press. In the case of the die used for piercing this shell, and all of the other dies referred to, it will be seen that a space is provided to allow the scrap and dirt to drop out at the bottom of the die.

Making a Sub-Press Die for Piercing and Shaving

The blank shown at *A* in Fig. 29 was the cause of considerable work, owing to the high degree of accuracy required. This blank had to be exactly interchangeable with either side up. Two sets of dies were made, *viz.*, a blanking die and a finishing or shaving die, and two sub-presses of the Blake & Johnson type were used. The blanking die was built in the usual manner. An allowance of 0.005 inch was left on all edges of the blank for shaving. The small holes were not pierced in the blanking operation but simultaneously with the shaving operation, as this method minimized the chance of error in locating the holes accurately in relation to the shaved surfaces.

The die for the shaving operation was built in the following manner. The die-plate *B* was made in two hardened and ground sections, inserted in a soft steel receiving holder as shown. By making this plate in two parts, it was possible to grind all surfaces. The large section of the die was first carefully laid out and the necessary boring and milling done. After hardening, the circular portion was first ground on a universal grinding machine. The straight walls were then ground with a saucer wheel on the surface grinder, the intersecting joint for the segment being ground off square at the same setting. Making the segment was a fairly simple job. It was relieved

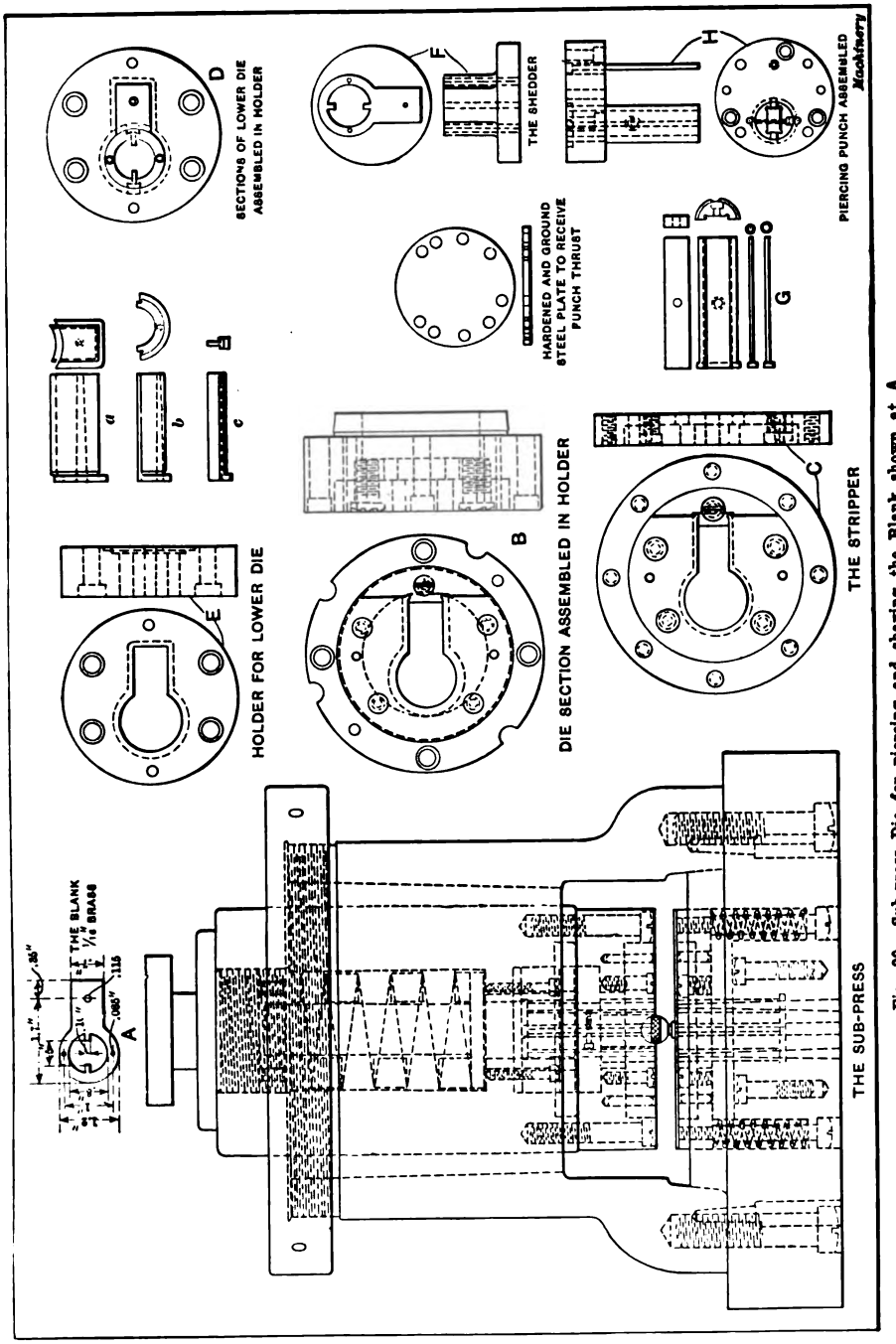


Fig. 29. Sub-press Die for piercing and shaving the Blank shown at A

in the corners after milling, to allow for grinding wheel clearance. The two parts were ground on the outside, while held on a solder chuck, to fit the soft receiving holder. The stripper *C* was made in precisely the same manner as the die, corresponding surfaces being machined at the same time.

The punch or lower die, which is shown assembled at *D*, required considerably more work. It was made in five parts which were hardened, ground and lapped all over. The part *a* was rough-planed and then mounted on a master plate in its correct position. The circular portion and the piercing hole were bored on the bench lathe; all the straight surfaces were then milled, 0.005 inch being left on all surfaces with the exception of the piercing hole, where 0.002 inch was left for truing up with a diamond lap. After hardening, the large circular portion was ground on the master plate. The remaining surface grinding was simple, care, of coure, being taken to make all surfaces square and in correct relation to the circular part as well as the piercing hole. The two circular sections *b* were worked up in one piece. The work was first bored and turned; it was then set up on the master plate and the two piercing holes were bored. After placing the part on a mandrel, the slots to receive the tongue pieces *c* were milled, sufficient stock being left for grinding. A wall 1/32 inch thick was left at the bottom of each slot to keep the two parts together until after hardening, which made the circular grinding much easier. After grinding, a thin saucer wheel was used to separate the two parts. The joints on each half were next ground at the same time, while the parts were soldered into a V-block.

The tongue pieces *c* were comparatively easy to make, requiring, of course, careful grinding. The grinding or truing up of the piercing holes was deferred until after the dies were assembled in the press. The five sections of the lower die were next assembled in the soft holder *E* which had been carefully bored and slotted. Care was taken that the sections did not fit so tightly as to cause springing of the parts. The shedder *F* was worked up "from the solid," all operations, as far as possible, being performed on the master plate. The piercing holes were left 0.002 inch small until after hardening; then the shedder was set on the master plate and the holes trued with a diamond lap.

The piercing punches are shown in detail at *G*, and mounted in their holder at *H*. The punch for piercing the large circular opening was made in three pieces. The center or spacing section is a plain rectangular shape as shown. The circular outside pieces were first milled to a little over grinding size. Each half was milled out through the center and relieved in the corners for wheel clearance. A screw hole was also drilled through all three parts. An arbor or mandrel was next milled square on each end, one end being the same size as the slot in the sections and the other end the finish size. The outside or circular surfaces were turned on one end of the mandrel, and after hardening the other end was used for grinding. The inner slot to

receive the rectangular section was ground out by holding the parts in a V-block so as to machine them both simultaneously. After assembling the sections in the holder and doweling them, the die work was practically completed.

The sub-press was allowed to run in the punch press for about a day, the bearing being tightened occasionally to insure a permanent bearing of the plunger in the cylinder. The centers of the plunger were then trued and the upper housing or frame was finished to fit the base concentrically. The base was then put on the faceplate and turned to a snug taper fit in the upper frame; at the same time the necessary boring was done to provide seats for the lower die or punch and the stripper plate. The plunger was again faced off and bored to form seats for the die and piercing punch pad.

After assembling the dies in the press, soft shoulder plugs were tapped lightly into the piercing holes in the lower die, while in the corresponding holes in the shedder, hardened and ground shoulder centers were tapped in. The press plunger was then carefully lowered until small center marks were made in the soft plugs; these centers were then indicated on the faceplate and diamond lapped true.

CHAPTER II

SECTIONAL PUNCH AND DIE CONSTRUCTION

A great many dies at the present time are formed of sections instead of being cut out of a solid piece of steel. This sectional construction is employed more particularly for large dies, especially when the form is complicated. The principal reason for making a die in sections, instead of from one solid piece of steel, is that the danger of spoiling the entire die, as the result of warping or cracking in hardening, is eliminated. On the other hand, a solid die is liable to be cracked by the hardening process, and in the case of a large die of complicated form this, of course, means a considerable loss. Some dies are also provided with one or more sections, at points on the die face where the work is severe, so that the die can easily be repaired by simply replacing these sections when they have been worn excessively.

Sectional Die for Piercing and Blanking Square Washers

An example of sectional die construction is shown in Fig. 30. This die is so designed that all the cutting edges and the inside of the die can be machined and ground to the required dimensions without requiring any hand work. This construction makes the punch and die inexpensive to produce, and in event of its being damaged during the hardening process or when placed in operation, the damaged parts can be renewed at a relatively small cost. The punch and die are used in manufacturing laminated copper washers in large numbers. These washers are square and have a square hole in the center; they are produced from sheet copper 0.020 inch in thickness. An inclined power press with automatic roll feed is used, and the finished work slides into a receptacle at the rear of the press.

By referring to the plan and sectional views of the die, it will be seen that there are three piercing and three blanking dies carried on one bolster. The die is made up of fifteen sections which are held together by double dovetail plugs fitting into corresponding holes. When ribbon stock is fed through the die, the holes in three washers are pierced at the first stroke of the ram, and at the next stroke the blanking punch cuts away three washers with the holes in their centers which were produced by the preceding stroke; at the same stroke, the holes are pierced for the next three washers. The diagram, Fig. 31, shows the order of the piercing and blanking operations. None of the sections of the die have been drawn in detail as they will be readily understood from the assembly drawing. All of the die sections are machined approximately to the required dimensions with the exception of the inside or cutting edges, which were left a few thou-

sandths over size to permit grinding them after hardening. The face is recessed on the outer edge to within ¼ inch of the cutting edge and ⅝ inch from the bottom, thus leaving a narrow strip all around the cutting edge in order to reduce the surface to be ground as far as possible.

Each section of the die is held securely to the cast-iron bolster *D* with one or two fillister screws, and the sections are then wedged

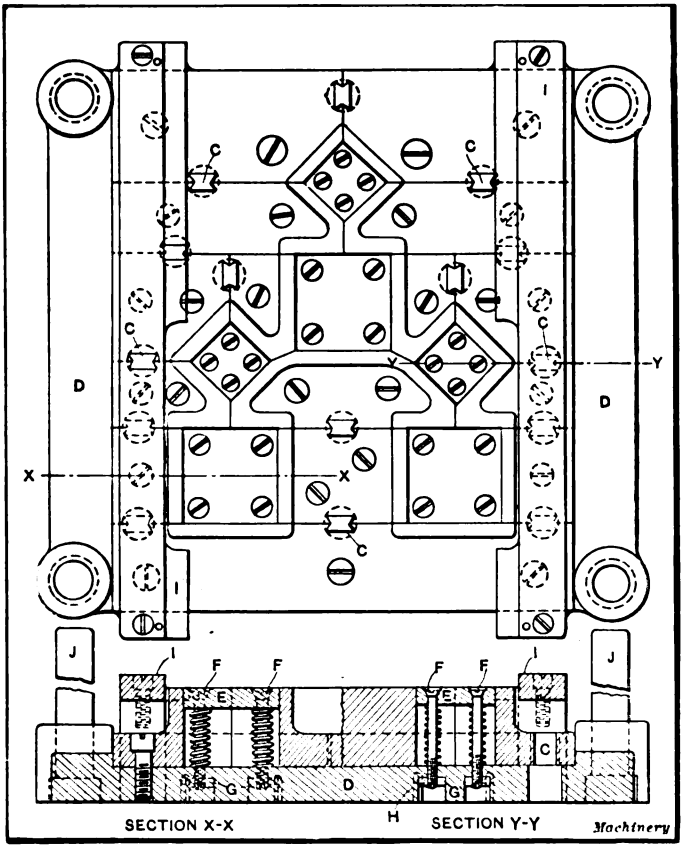


Fig. 30. Plan and Sectional Views of Blanking and Piercing Dies

together with double dovetail blocks *C*. The cutting edge of each section is only hardened down about ⅜ inch and is drawn to a light straw color. When all the sections are assembled on the bolster *D*, the double dovetail holes are laid out with a templet and each of the sections is then milled with a dovetail cutter to receive the clamping blocks *C*. The blocks are made of tool steel, in strips 12 inches long; these strips are then sawed up into pieces ⅝ inch in length and the ends are filed to a slight taper so that they will just enter the holes between the die sections. These blocks are hardened in oil and drawn

to a blue color. The die sections are next screwed to the bolster and the dovetail wedges are driven in; this method of fastening holds the die as securely as if it were a single piece.

Each of the piercing and punching dies is equipped with an ejector plate *E* which is a sliding fit in the holes and held in position with four flat head screws *F*. Spiral springs are placed around these screws to hold the ejector plates in position. The screws *F* extend through the bolster and carry adjusting nuts *G* which fit in counterbored holes on the under side of the bolster. Small holes are drilled in the under side of the bolster, before the counterbored holes for the adjusting nuts are bored. These small holes are then plugged up to keep the drill from running out while counterboring the larger holes for the nuts *G*. When the plugs are removed from the small holes, the portion of the hole which was not removed during the counterboring operation serves as a guide in drilling a hole to receive the small pin *H* which is tapped into the nut *G* and keeps it from turning. The ejectors are adjusted by means of the screws *F* so that they are about 1/32 inch above the cutting edge of the dies. A long guide plate *I* is placed at each side of the die and fastened in position with fillister screws and a dowel pin on each end.

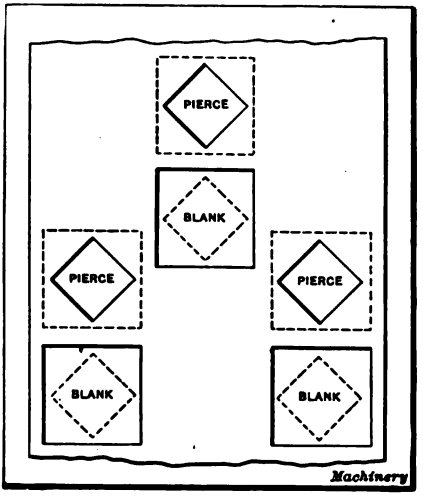


Fig. 31. Diagram showing Piercing and Blanking Operations on Ribbon Stock

The cast-iron bolster plate *D* is planed on the bottom and top and also across the bosses. The four holes in each corner are next drilled, reamed and counterbored to receive the sub-press pins *J*, similar holes being made in the punch holder after the punch and die have been assembled. The sub-press pins *J* are made of tool steel hardened up to the head; the heads are ground to a driving fit in the die bolster and the pins are ground to a sliding fit in the punch holder. To locate the holes for these pins in line with each other, and also to have them square with the punch and die, the following method was used: After the punch and die were hardened and assembled, two parallels were placed between the bolsters. The punch was placed inside the die and the punch and die clamped together with four C-clamps. After the work had been clamped in this way the holes were bored in the punch holder through the holes in the die bolster, and were consequently in perfect alignment.

Fig. 32 shows plan and sectional views of the blanking and piercing punches *A* and *B*, which are made of tool steel and left soft.

These punches are secured to the cast-iron holder *C* by means of two fillister screws and two dowel pins. In order to locate the punches in proper alignment with the die, the punches are first marked so that they can be replaced in the same positions. The ejectors are then taken out of the die, and blocks made of ¾-inch cold-rolled steel are placed in the die holes in their places. These parallel blocks are faced off to the proper height to bring them 1/16 inch below the cutting edge, all six of the blocks being of the same height. The punches

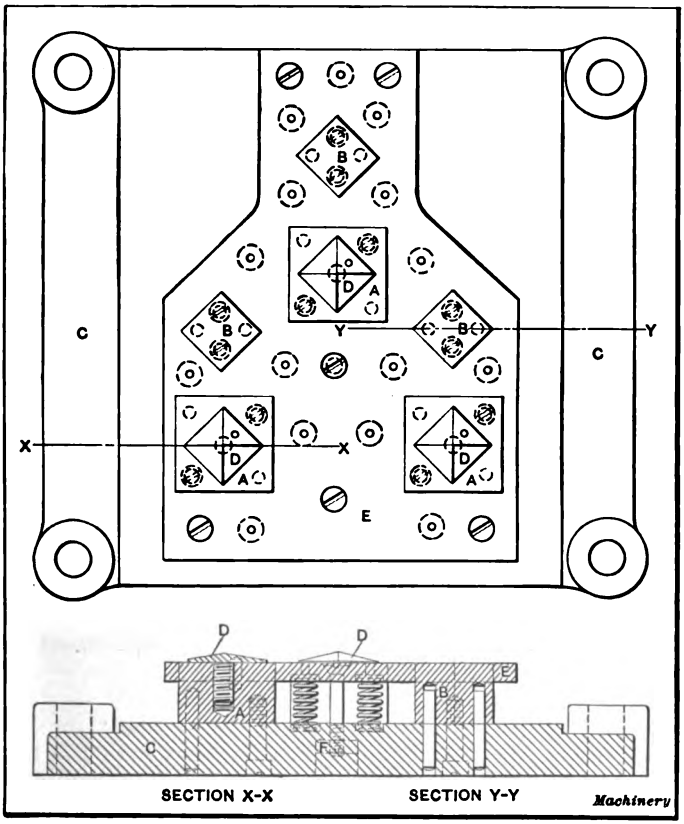


Fig. 32. Plan and Sectional View of Blanking and Piercing Punch

are next placed in their respective die holes and the punch holder *C* is then slipped over the four sub-press pins in the die bolster and lowered onto the punches. With a right angle scratch-awl, lines are marked on the punch holder to locate the four sides of each punch, the scriber being worked through the screw holes in the die bolster. The punch holder is next withdrawn, and from the outlines of the punches on the holder the four holes for each punch are located, drilled and counterbored to receive the two set-screws and the two dowel pins.

When all of these holes are drilled in the holder, the latter is once more replaced on the punches and secured with four C-clamps. Care must be taken not to twist the punches and also to see that the two bolsters are parallel with each other. All of the screw and dowel pin holes are now drilled into the punches to a depth of about 1/32 inch, the holes in the punch holder serving as a guide. The C-clamps are now loosened and the punch holder removed; all of the punches are then taken out of the die and the holes are drilled to the required depth, after which the screw holes are tapped. When this work has been finished, the punches are replaced in their respective positions on top of the blocks in the die. Care must be taken to have all the chips removed and the work perfectly clean. The punches are secured with screws and the two bolsters again strapped together with four C-clamps; straight dowel pin holes are then reamed through the bolster into the punches. In that way all of the punches and subpress pins are in perfect alignment.

Pilots *D* are screwed on top of the three blanking punches to guide the metal during the blanking operation. These pilots enter the holes in the washers which were pierced by the preceding stroke of the ram, and prevent the work from twisting. These pilots are held in place by a screw and a dowel pin. A stripper plate *E* made of 5/16-inch cold-rolled steel surrounds the punches and is held in position by the tension of fifteen springs. This stripper plate is made to fit between the guides *I* (Fig. 30) on the die and is a free fit on the outside of the punches. The stripper plate is adjusted by the flat-headed screws and nuts *F*. It will be noticed that there is a small hole in the center of each spiral spring seat. These holes are made in the following manner: All of the holes in the stripper plate are laid out in the usual way and drilled through with a ⅛-inch drill; the stripper is then placed on the bolster with all of the punches in position and the holes are transferred through onto the bolster. The spring seats can now be counterbored on the stripper and bolster and by this means all of the spring seats will be in perfect alignment with each other.

Sectional Die for Linotype Type Bar Plates

A punch and die for producing the type bar plates for linotype machines is illustrated in Fig. 33. These plates have one hundred rectangular holes 0.060 by 0.360 inch in size, and the bar is 0.03 inch thick. One of these plates is attached to the under side of each linotype machine for holding the end springs which return the type bars after the keys are struck by the operator. It is necessary to have these type bar plates made with considerable accuracy; the holes must be of the size specified, there must be the proper space between them, and their sides must be parallel and perpendicular, respectively, with the edges of the plate. Evidently these conditions would make it very difficult, if not impossible, to produce plates of this type with a single punch and die and some suitable form of spacing mechanism.

Several attempts were made to produce a punch and die for this purpose before a successful device was hit upon. In the first case,

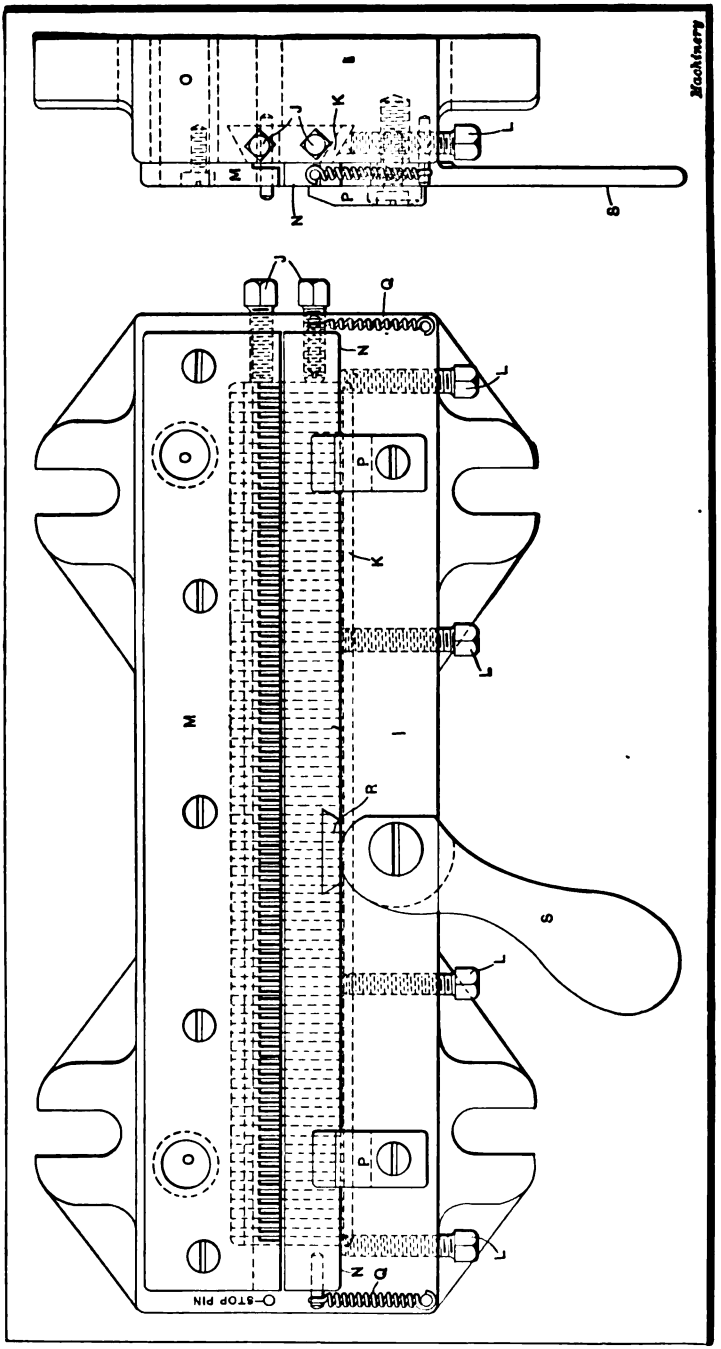


Fig. 33. Plan and End Elevation of Die made in Sections

the punch and die appeared to be satisfactory after it was finished, but had only run a few days when one of the bridges caved in to such an extent that attempts to repair it were unsuccessful. The second punch and die was of similar design to the first, except that special means were taken to strengthen its construction. When this die was inspected after hardening, however, it was found that two of the bridges were cracked in the corners. It was then decided to make a sectional form of punch and die which would enable individual parts to be replaced when broken or worn in service, without necessitating the construction of an entirely new tool. The die section adopted for this purpose is indicated at *B* in Fig. 35. It will be seen that two 5/16-inch holes are drilled and reamed through these sections, pieces of drill rod being used to hold the sections together in a 30-degree bolster; the sections were wedged in this bolster by means of a suitable gib and set-screws. This die also proved a failure because no provision had been made for guide posts or pilots. The result of this omission caused the die to shift while in service, so that the punches were stripped to such an extent that they became absolutely useless. The difficulties met with in early forms of dies for producing these type bar plates are mentioned in order that the same trouble may be avoided by other shops that are called upon to produce punches and dies of this type for similar classes of work.

Fig. 33 represents the form of sectional die which was finally developed for this operation. All parts of this tool which are likely to be worn or damaged in operation are made interchangeable, duplicate parts being kept in stock so that they can be placed in service when required. The die pieces are machined to the required dimensions, allowing 0.005 inch for grinding and lapping. One of the die sections *C* is shown in Fig. 35. In order to machine these parts so that the slot would be the same distance from the inclined sides of the bolster, the milling fixture (also illustrated in Fig. 35) was designed for producing them. The cast-iron block of this fixture is held in an ordinary milling machine vise and the pins *E* and *F* are so placed that the blank for the die sections will be held at an angle of 60 degrees. The strap *G* holds the work in position while milling; all of the pieces are first milled at one end to an angle of 30 degrees, after which they are turned over in the fixture to have their opposite ends milled in a similar manner. Before starting the section milling operation, the machine is set to produce pieces of the required length, and it will be evident that this method of production insures having all the die sections of exactly the same size. The same fixture is used for milling the slot in the die section; for this purpose the fixture is swung around 30 degrees and a cutter 0.360 inch wide is used, the slot being cut 0.060 inch deep. The three sides of the slot are now relieved with a file and after being hardened and drawn at a light straw color, the sections are ground on both sides so that the section through the slot will just enter the 0.060 inch space in the gage *H*,

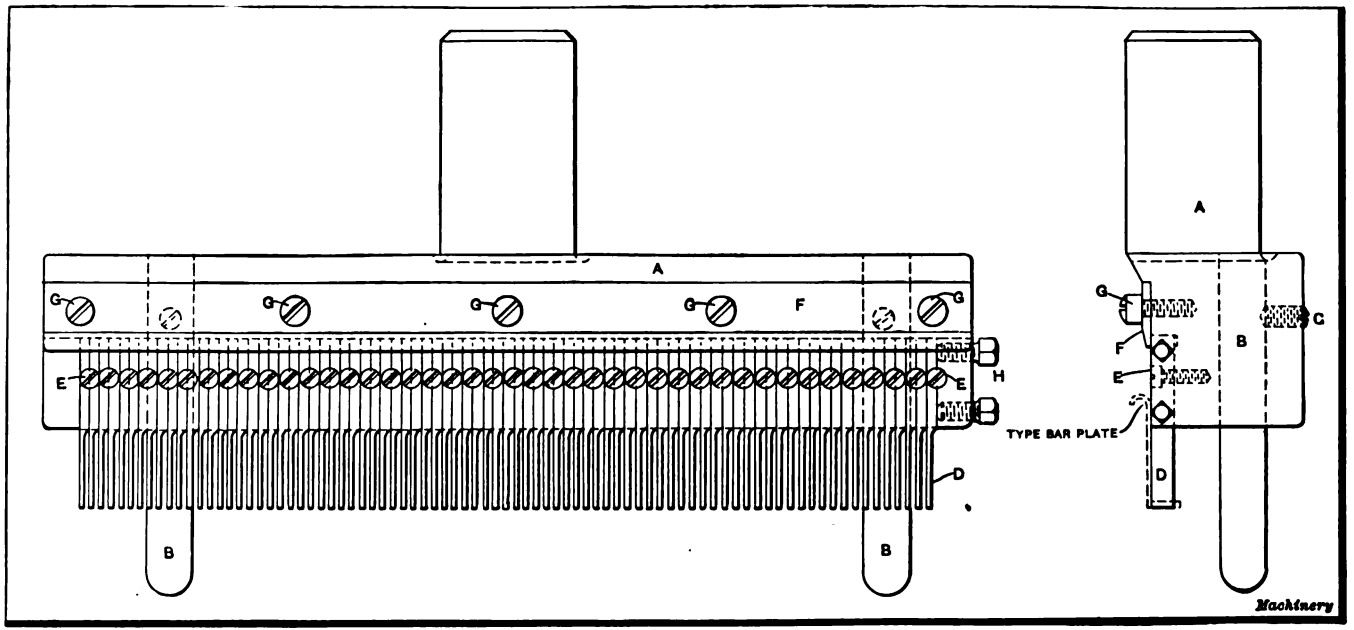


Fig. 34. Side and End Elevations of Punch made in Sections

and the thicker section will enter the 0.120 inch space. The bottom and angles are not ground, but the top of all the sections are ground when they are assembled in the cast-iron bolster *I*, Fig. 33. Two set-screws *J* are provided to take care of the end thrust on the die sections. The length of the die is 9 inches, but if it is found that this dimension is slightly exceeded, it is an easy matter to lap the sections off on the sides to reduce it the required amount.

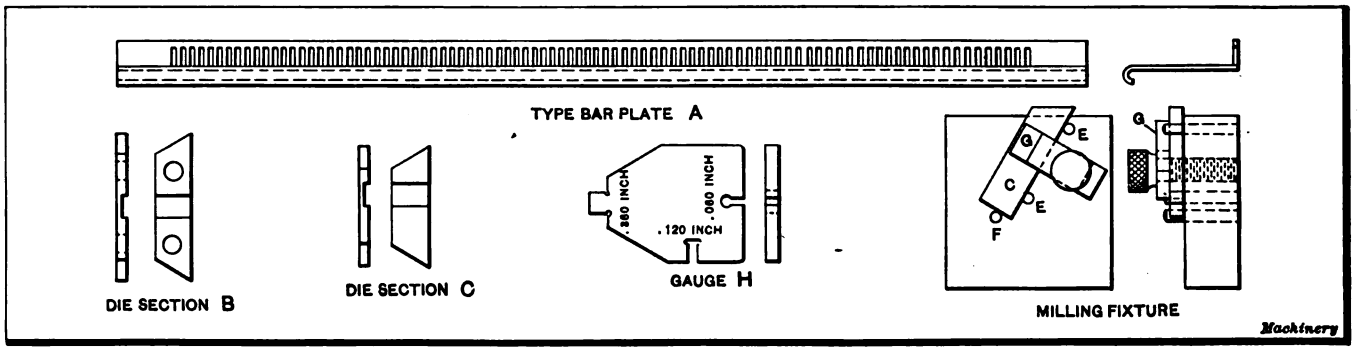


Fig. 35. Type Bar Plate A, Die Sections B and C, Gage H, and Milling Fixture for making Die Sections

The cast-iron bolster is held securely to the press bed by means of four ⅝-inch hexagon screws. The gib *K* runs through the entire length of the die bolster and is held against the die sections by four set-screws *L*. On top of the bolster, there are two soft-iron plates *M* and *N*. The plate *M* is held in position by five fillister screws and acts as a stop-wall for the work to rest against in the die. This plate has slots milled along its edge which correspond with the die section, only they are a few thousandths larger than the punches; the plate *M* also acts as the stripper for the punch. The plate *N* slides back and forth on the bolster under the strap *P*, its movement being controlled by the cam and lever *S*. The hardened wedge *R* is driven into the middle of the plate for the cam *S* to rest against and when the cam is swung around to bring the flat section into engagement, the springs *Q* at each end of the die pull the plate *N* back so that sufficient space is made to lift the finished work out of the die.

There are two ¾-inch holes *O* provided in the bolster to receive the pilots *B* of the punch-holder, Fig. 34. These holes have hardened bushings driven into them which can be replaced when they become worn to an objectionable extent. The punch sections are held in a machinery steel holder *A* shown in Fig. 34. This holder is finished all over, great care being taken to secure the necessary alignment. The guide pins *B* are hardened, ground and lapped to exact dimensions and the same gage *H* (Fig. 35) that was used for measuring the die sections is also used in determining

the accuracy of the punch sections. These punch sections are secured to the holder by fillister screws *E*, a single screw being used between two sections in the manner shown in the illustration. The clamp *F* runs the entire length of the holder and is held in position by the fillister screws *G*. Two set-screws *H* are provided to take up any end thrust in the punch sections.

It may appear that this punch and die is rather complicated, but this design seemed to be the only one that could be maintained in working condition; moreover the working parts are relatively simple, and were not as expensive to make as it might appear. The forming of the type bar plates *A* (Fig. 35) is done in two operations. The stock is rolled on a spool and held in the proper position to be received by a powerful trimming press. In the first operation, the stock

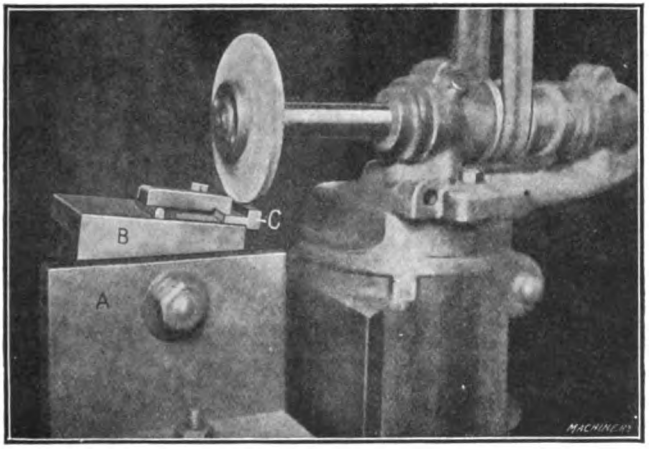


Fig. 36. Grinding the Die Sections

is cut off and formed to the right angle; the downward stroke of a roller at the back of the die then curves the other edge of the plate upward to form a quarter segment. The second operation is done separately in a clamping die and forms the plate to the required shape.

Making Sectional Die Parts

The making of sectional dies for armature disks and work of a similar kind calls for considerable ingenuity on the part of the toolmaker in devising means for producing these parts accurately and economically. It is necessary, if the best results are to be obtained, to secure a steel which will not warp or distort during the hardening process so that grinding of the parts after hardening need not be resorted to. Should the die and punch sections warp or shrink, it adds greatly to the difficulty of manufacturing the parts and greatly increases the cost of the tool. In many cases grinding of the die and punch sections is necessary, so that special devices and tools have been

devised for handling this work as expeditiously as possible. In the following pages, a number of the most interesting methods employed by the Columbus Die, Tool & Machine Co. will be given. This company makes a specialty of producing for various firms punches, dies, tools and special equipment, and therefore is in a position to devise means for getting this work out in the shortest possible time.

Grinding the Die Sections

In order that the die sections will fit properly in place after hardening and give the required outside and inside diameters, it is necessary

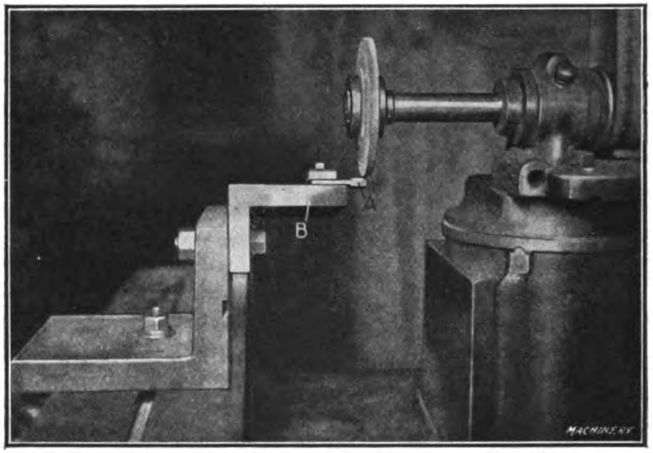


Fig. 37. Grinding the Punch Sections

to leave a slight amount of excess stock on the sides of the sections that fit against each other in the die holder. These sides are then ground to the required angle and thickness in a special fixture. The toolmaker figures out the required angle of the side sections and also the least or greatest thickness. The type of fixture used for grinding these die sections is shown in Fig. 36. It consists of an ordinary angle-plate *A* which is fastened to the table of a grinder of the surface type, and against which is held another angle-plate *B* that can be set around to the desired angle and carries the work to be ground. The work or die section *C* in this case is held in place by a special toe clamp, and when one side of the section is ground it is reversed and the other side is ground.

The sides of the punch sections are ground in a similar manner on the same fixture which, however, is swung around into the position shown in Fig. 37. The punch section *A* is held to the small angle-plate *B* as illustrated, and when one side is ground the section is reversed on the angle-plate and the other side finished. When the fixture has once been set up, however, all the punch or die sections are ground on one side first. Then the setting of the machine is changed and the other side of all the sections ground. This enables

the toolmaker to turn out the work much more quickly than if he were to reset the machine for both sides of the piece, thus finishing it complete without removing it from the fixture to put another in its place.

Special Chucks for Holding Die and Punch Section while Grinding

In Fig. 38 are shown two special chucks which are used for holding punch and die sections while grinding the inside and outside diameters

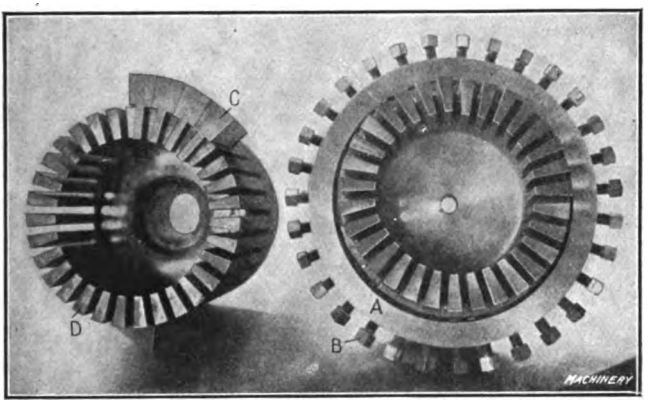


Fig. 38. Special Chucks for holding Die and Punch Sections while Grinding

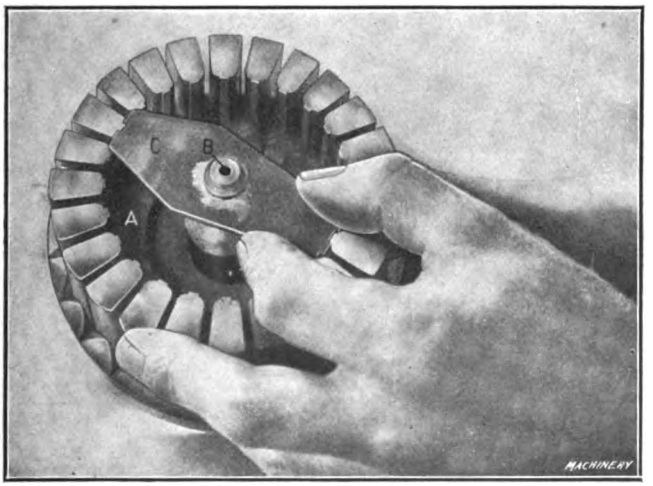


Fig. 39. Assembling a Sectional Armature Disk Punch

and the top and bottom faces, so that all the important machined surfaces can be finished at the same setting. The special chuck for holding the punch sections is shown to the right of the illustration. This, as can be clearly seen, consists of a cup-shaped body *A* around

the periphery of which are located set-screws *B*. These set-screws bear against the backs of the sections and bind them together, the beveled surfaces of the punch sections being wedged together by the action of the set-screws, and consequently held rigidly in place for the grinding operation. The grinding is done in a cylindrical grinding machine, the chuck being screwed to the nose of the spindle in the ordinary

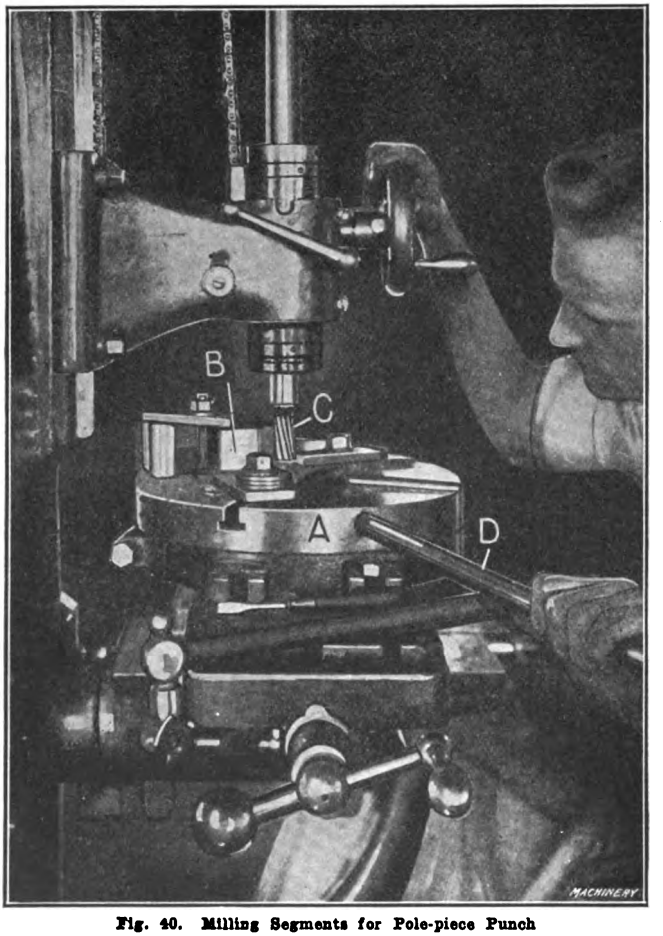


Fig. 40. Milling Segments for Pole-piece Punch

manner. The outside surfaces are ground tapered to an angle of 5 degrees to enable them to be held in place in the punch holder by a retaining ring.

The special chuck for holding the die sections for grinding is shown to the left of the illustration. Here only four die sections *C* are shown in place, simply to indicate the manner in which they are held. The narrow portion of the die section is a drive fit in the slots of the

die holder and these sections are tapped lightly into place until the beveled surfaces contact. The chuck *D* is also held in a cylindrical grinder, being screwed to the nose of the spindle as previously mentioned in connection with the chuck for the punches. This chuck enables the inside and outside diameters of the die sections to be ground and also the top face. The lower face is ground by reversing the position of these machines in the chuck, and then holding them in the manner in which they are held in the illustration.

Assembling an Armature Disk Punch

After the beveled sides of the punch sections have been ground, it is then necessary to test these sections to see whether the correct

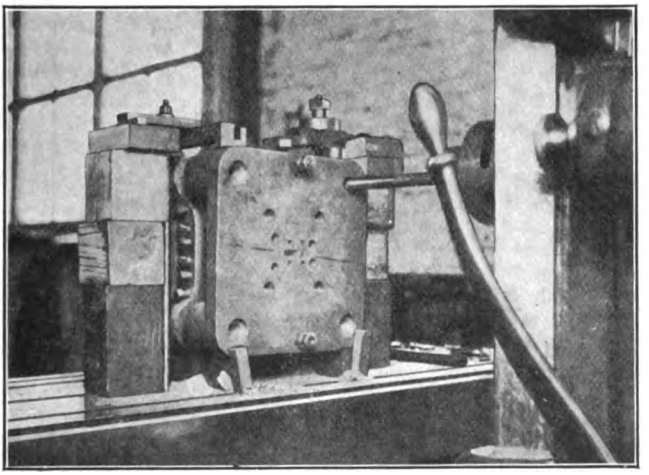


Fig. 41. Boring Sub-press Die Guide Pin Holes

inside and outside diameters have been secured, and also if the small projections on the inner surfaces of the punch sections are properly located axially. This, of course, proves whether the correct amount of stock has been ground from the sides of the punch sections. The fixture used for this purpose is shown in Fig. 39 and consists of a block *A*, circular in shape, in which a stud *B* is located. This stud acts as a means for holding the gage *C*, which, as can be seen, is cut to fit over the projections on the punch sections and is also fitted over the stud, being centrally located in this manner. In this particular case, a limit of only 0.0005 inch is allowed from the center of the plug to the inside face of the punch section. Also the blank must be reversible on the punch. When it is realized that these dimensions are governed entirely by the amount of metal removed from the sides of the sections, it will be seen that the grinding operation is one that must be very carefully handled and that requires considerable ingenuity on the part of the toolmaker if the parts are to assemble accurately.

Milling Segments for Pole-piece Sectional Punches

Fig. 40 shows how segments for pole-piece sectional punches are milled both on their circular and angular faces. A Knight milling and drilling machine is used for this purpose, being equipped with a circular milling attachment *A*. The section *B* of the pole-piece punch to be machined is clamped to the top face of the circular milling attachment by clamps as illustrated, and the machining is accomplished by an end-mill *C* held in the spindle of the machine. The circular attachment is operated by a bar *D* which can be located in holes provided around the periphery of the faceplate. For milling the beveled faces, the circular attachment is clamped to prevent it from rotating and the feed-screw for the table is operated.

Boring Sub-Press Die Guide Pin Holes

After all the various members of the sectional punch and die have been completed, they are assembled in the punch and die holders and then the next operation is to bore the holes for the aligning pins, when the dies are of the sub-press construction, which is the usual type of construction adopted for complicated sectional punches and dies. The manner in which these guide pin holes are machined is shown in Fig. 41. The punch and die holder are located in the proper relation to each other and are fastened together by through bolts as illustrated. Then these holders for the sectional members are located on the table of a milling machine and the holes are first drilled and then bored by a boring tool held in the spindle of the machine. The two lower holes are bored and counterbored first, the center distances, of course, being located by the micrometer dial on the feed-screw. Then the table is lowered and the top or two remaining holes are bored and counterbored in a similar manner. This method of boring the guide pin holes enables them to be produced quickly and accurately with very little difficulty.

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